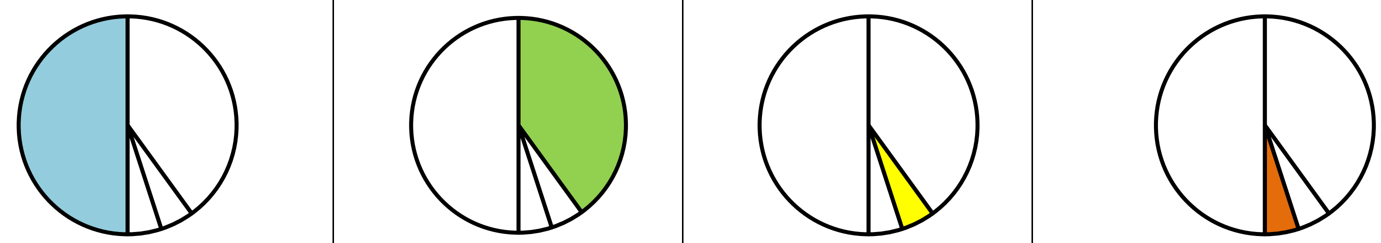
RISK SCORE INPUTS

LIKELIHOOD	IMPACT	WARNING TIME	DURATION
[50%]	[40%]	[5%]	[5%]



RISK = LIKELIHOOD + CONSEQUENCE

HAZARD IDENTIFICATION AND RISK ASSESSMENT

HOWARD COUNTY, MARYLAND

2020

THIS DOCUMENT WAS DEVELOPED BY THE HOWARD COUNTY OFFICE OF EMERGENCY MANAGEMENT

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<u>SECTION 1</u>
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TABLE OF CONTENTS

SECTION 2

INTRODUCTION AND BACKGROUND

Introduction and Background

Contents of this Section

I. INTRODUCTION

This section discusses the guidance and strategic goals that influenced the planning process.

The Hazard Identification and Risk Assessment (HIRA) is a comprehensive analysis of manmade and natural hazards which could impact Howard County, Maryland. The initial HIRA was developed between the years 2014 and 2015 to serve as a foundational document for emergency preparedness planning efforts within Howard County. Development of the HIRA was led by the Howard County Office of Emergency Management (OEM). The HIRA reflects a whole-community approach to risk assessment involving local government stakeholders, private-sector partners, and private citizens.

Overview

This section provides an overview of the sections.

The HIRA is broken into six sections and two annexes:

Section 1: Table of Contents

Section 2: Introduction and Background
An overview of the HIRA, key terminology, and the HIRA approach to risk assessment.

Section 3: Risk Management and Planning
A guide for using the HIRA to support preparedness and response efforts.

Section 4: Planning Process
An overview of the HIRA strategic plan, the planning process, and participating partners.

Section 5: Interpreting the Hazard Profiles
A guide to understanding the information contained in the HIRA hazard profiles.

Section 6: Risk Overview
An overview of the HIRA results.

Section 7-8: Hazard Profiles, Manmade and Natural Hazards
Complete risk assessments of each HIRA hazard.

Scope and Organization

This section details the hazards addressed by the HIRA and the organization of information within each hazard profile.

The HIRA provides an in-depth profile, risk assessment, and consequence analysis of 13 manmade hazards and 10 natural hazards. The hazards addressed by the HIRA include:

MANMADE HAZARDS	NATURAL HAZARDS
1. Active Assailant 2. Biological Hazard 3. Chemical Hazard 4. Civil Unrest 5. Cyber Hazard 6. Dam Failure 7. Emerging/Re-Emerging Infectious Diseases 8. Explosives Hazard 9. Nuclear Hazard 10. Radiological Hazard 11. Structure Fire 12. Transportation Hazard 13. Utility Disruption Hazard	1. Drought 2. Earthquake 3. Flood 4. Hurricane/Tropical Cyclone 5. Lightning 6. Pest Infestation/Zoonotic Infection 7. Severe Winter Weather 8. Solar Storm 9. Tornadoes/Wind Storm 10. Wildfires

Each hazard profile included in the HIRA is organized into the following sections and sub-sections:

I. OVERVIEW
- Definition
- Risk Profile
- Risk Matrix
- Risk Ranking

II. HAZARD CHARACTERISTICS
- Description of the Hazard
- Local Context

III. LIKELIHOOD ANALYSIS
- Occurrence of the Hazard
- Future Likelihood of the Hazard

IV. CONSEQUENCE ANALYSIS
- Consequence Overview
- Consequence Analysis: Likely Hazard Scenario
- Consequence Analysis: Worst-Case Hazard Scenario
- Public Perception

Additional information on the organization and content of the hazard profiles can be found in Section 4: Interpreting the Hazard Profiles.

II. KEY TERMINOLOGY

This section defines key words and phrases that will be used throughout the HIRA.

Communicating risk-related concepts can be challenging. Many of the terms used in risk assessment have colloquial meanings that confuse and distract from the intended message. The following definitions are established and expanded upon in the U.S. Department of Homeland Security (DHS) Risk Lexicon[1] and will be used throughout the HIRA:

ASSET

A person, structure, facility, information, material, or process that has value.

CONSEQUENCE

The effect of an event, incident, or occurrence. Consequence in the HIRA includes impacts to property, health and safety, critical facilities, response capacity, the environment, the economy, and standard of living/quality of life. Analysis of consequence in the HIRA also incorporates the Warning Time and Duration of the hazard.

EMERGENCY-LEVEL HAZARD EVENT

A hazard event that requires a response from at least two Howard County agencies or partners.

HAZARD

A potential source or cause of harm or difficulty. A hazard can be natural or manmade.

LIKELIHOOD

The conditional probability of observing a particular event in a given span of time.

MANMADE HAZARD

A hazard that originates in some way from human activity.

NATURAL HAZARD

A source of harm or difficulty created by a meteorological, environmental, or geological phenomenon.

RISK

The potential for an unwanted outcome resulting from an event. Risk is a function of the hazard likelihood and its associated consequences.

THREAT

An occurrence that has the potential to cause harm or difficulty. Unlike hazards, threats are always directed at an entity, asset, system, network, or geographic area. For the purpose of calculating risk, the threat of an intentional hazard is generally estimated as the likelihood of an attack.

VULNERABILITY

A physical feature or operational attribute that renders an entity, asset, system, network, or geographic area open to exploitation or susceptible to a given hazard. In calculating the risk of an intentional hazard, the common measurement of vulnerability is the likelihood that an attack is successful.

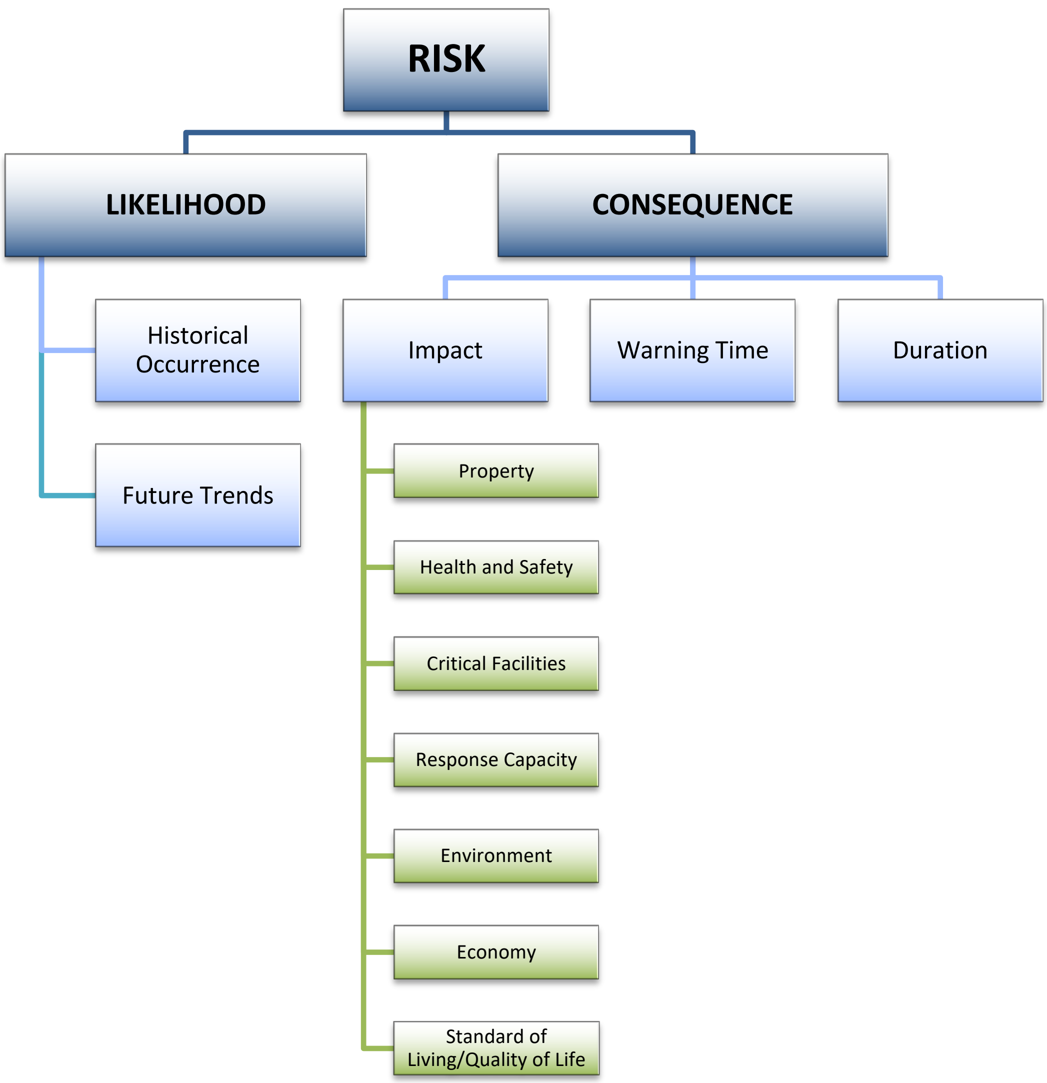
[1] *DHS Risk Lexicon: 2010 Edition*, U.S. Dept. of Homeland Security Risk Steering Committee (2010). Available at https://www.dhs.gov/xlibrary/assets/dhs-risk-lexicon-2010.pdf (last accessed November 26, 2019).

III. ASSESSING RISK AT THE COUNTY LEVEL

This section discusses the components of risk as they are evaluated in the HIRA.

There are many ways to assess risk. In its most basic form, a risk assessment is a process that collects information and assigns values to risks. Risk values can be used for the purpose of informing priorities, developing or comparing courses of action, and informing decision making.

Risk is most easily understood by analyzing the component parts of risk. The HIRA defines the components of risk in the following manner: Risk is a function of Likelihood and Consequence. Likelihood is defined by historical occurrence and future trends. Consequence is defined by Warning Time, Duration, and Impact. Impact itself is defined by impacts to Property, Health and Safety, Critical Facilities, Response Capacity, the Environment, the Economy, and Standard of Living/Quality of Life. The chart below demonstrates this relationship visually:



In the field of risk assessment, there are several approaches to understanding the components of risk. Below are two examples of how to understand a risk:

*RISK = LIKELIHOOD * CONSEQUENCE*

OR

*RISK = THREAT * VULNERABILITY * CONSEQUENCE*

While the HIRA understands risk as a function of likelihood and consequence (commonly written as *RISK = LIKELIHOOD * CONSEQUENCE*), it is also common to see risk demonstrated as a function of threats, assets, vulnerabilities, and/or consequences (commonly written as some variation of *RISK = THREAT * VULNERABILITY * CONSEQUENCE*).

Although they appear quite different, there is significant overlap between the variables measured by these two approaches. The latter approach is most effective when assessing the risk of targeted threats to specific assets. The likelihood/consequence formula used by the HIRA was chosen for its effectiveness when measuring and comparing all hazards (not just targeted threats) where the asset at stake is the entire County.

The approach used by the HIRA was designed to be easily adaptable for a wide variety of planning purposes. Guidance for applying the information contained in the HIRA can be found in the Risk Management and Planning section.

The Howard County Risk Tool

This section outlines the tool developed by the HIRA to evaluate hazard risk.

The Howard County Risk Tool is the key to understanding and interpreting hazard risk. The Risk Tool converts hazard information into a set of numerical scores that allow for comparison across many natural and manmade hazard types. With the appropriate information, any hazard can be processed through the Risk Tool for comparison with HIRA data. Similarly, any existing HIRA risk score can be easily interpreted by referencing the quantitative levels outlined in the Risk Tool. The tool has been designed so that the resulting risk score is transparent, replicable, and scientifically defensible.

The Risk Tool reflects the components of risk outlined earlier in this section. Every hazard is assigned a numerical score in each of the four risk assessment categories: Likelihood, Impact, Warning Time, and Duration. Numerical scores range from 1 to 4 based on criteria that are defined explicitly in the tool. The scores from each section are multiplied by the assigned weighting factor. Likelihood is weighted at 50% of the Risk Score. Consequence is made up of Impact (40%), Warning Time (5%), and Duration (5%) for a combined total of 50% of the Risk Score. Once multiplied by the weighting factor, the sum of the scores becomes the total Risk Score for the hazard. This process is explained in detail in the Overview Guide, Risk Profile in Section 5, Interpreting the Hazard Profiles and is shown in the table below.

<table>
<tr><th colspan="5">Risk Profile</th></tr>
<tr><td rowspan="2">LIKELIHOOD</td><td>Risk Assessment Category</td><td>Likely Hazard Scenario</td><td>Worst-Case Hazard Scenario</td><td>Weight</td></tr>
<tr><td>Likelihood</td><td colspan="2">2.75
Infrequent-Likely</td><td>50%</td></tr>
<tr><td rowspan="3">CONSEQUENCE</td><td>Impact</td><td>1.8
Limited-Significant</td><td>3
Critical</td><td>40%</td></tr>
<tr><td>Warning Time</td><td>4
Short</td><td>4
Short</td><td>5%</td></tr>
<tr><td>Duration</td><td>1
Short</td><td>1
Short</td><td>5%</td></tr>
<tr><td colspan="2">TOTAL RISK SCORE</td><td>2.3</td><td>2.8</td><td></td></tr>
</table>

HOWARD COUNTY RISK TOOL

LIKELIHOOD FACTORS

LIKELIHOOD

Estimated chance of a single hazard event occurring in a given year based on historical incidence and trend forecasting.

UNLIKELY (1)	INFREQUENT (2)	LIKELY (3)	VERY LIKELY (4)
No documented occurrence. Less than 1% chance of annual occurrence.	1-10% chance of annual occurrence.	11-30% chance of annual occurrence.	30+% chance of occurrence annually.

CONSEQUENCE FACTORS

IMPACT

Estimated effect of a single hazard event on property, health and safety, critical facility functioning, response capacity, the environment, the economy, and standard of living.

LIMITED (1)	SIGNIFICANT (2)	CRITICAL (3)	CATASTROPHIC (4)
▪ Property damage is less than 5% of critical and non-critical infrastructure. ▪ Injuries are manageable with existing resources, no fatalities. ▪ Shutdown of critical facilities for less than 24 hours. ▪ Local resources are adequate to support the response. ▪ Little to no environmental impact. ▪ Little to no economic impact. ▪ Standard of living is only minimally disrupted.	▪ Property damage is 5-25% of critical and non- critical infrastructure. ▪ Injuries are manageable, may include at least one death. ▪ Critical facilities are down for 1-7 days. ▪ Local and mutual aid resources are adequate to perform response, with limited or no state assistance. ▪ Moderate environmental impact. ▪ Moderate economic impact. ▪ Standard of living is moderately affected.	▪ Property damage is between 26-50% of critical and non-critical infrastructure. ▪ Multiple deaths and serious injuries are probable. ▪ Shut down of critical facilities 1-4 weeks. ▪ Local resources are expended and require sustained support from mutual aid partners and/or the state/federal government. ▪ Serious environmental impact. ▪ Serious economic impact. ▪ Standard of living is seriously affected.	▪ Property damage is severe, greater than 50% of critical and non-critical infrastructure affected. ▪ Multiple deaths and serious injuries exceed jurisdiction response capacity. ▪ Shut down of critical facilities will be more than one month. ▪ Response capacity is overwhelmed and requires significant and long lasting state and federal government support. ▪ Severe environmental impact. ▪ Severe economic impact. ▪ Standard of living is extremely impacted and may not be fully recoverable.

WARNING TIME

Estimated time of awareness prior to the onset of the hazard event.

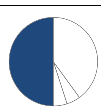
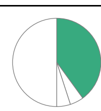
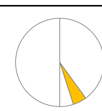
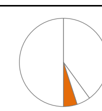
VERY LONG (1)	LONG (2)	MODERATE (3)	SHORT (4)
More than 24 hours	12-24 hours	6-12 hours	Less than six hours

DURATION

Estimated time from onset to conclusion of the hazard event.

SHORT (1)	MODERATE (2)	LONG (3)	VERY LONG (4)
Less than six hours	6-24 hours	Less than one week	More than one week

RISK SCORE WEIGHTING

LIKELIHOOD	IMPACT	WARNING TIME	DURATION
[50%]	[40%]	[5%]	[5%]
			

RISK = LIKELIHOOD + CONSEQUENCE

SECTION 3
RISK MANAGEMENT AND PLANNING

Risk Management and Planning

Contents of this Section:

I. PLANNING WITH THE HIRA

The Overview section defines the hazard and summarizes the hazard risk profile.

The HIRA was developed to be used for a wide variety of planning and risk management purposes. Data contained in the HIRA can be easily integrated into new and existing plans. Integrating information from the HIRA encourages a data-driven approach to preparedness decision making.

Benefits of using the HIRA include:

- Improving risk communication by establishing a common language
- Setting data-driven planning priorities
- Justifying existing planning priorities
- Evaluating and comparing prevention, protection, and mitigation actions
- Anticipating challenges during an emergency event

Establishing a Common Language

This section describes how to use the HIRA to add consistency and clarity to planning efforts.

The risk terminology used in the HIRA is consistent with existing guidance and has been vetted and approved by a select committee of representatives from Howard County's various emergency management stakeholder organizations. Referencing hazards using HIRA-established terminology allows for easy and accurate communication of ideas and helps promote the perception that all Howard County planning documents are working toward the same shared goals.

Example: Integrating consistent HIRA terminology into an existing plan.

> The agency has taken steps to prepare for all ~~emergencies~~ hazards. The agency has taken special steps to prevent ~~attack hazards~~ Adversarial/Intentional hazards. The agency is particularly concerned about ~~gunmen and bombs~~ Active Assailant hazards and Explosives hazards. The agency recognizes the risk posed by hazards in the communit~~y~~ as described in the Howard County Hazard Identification and Risk Assessment.

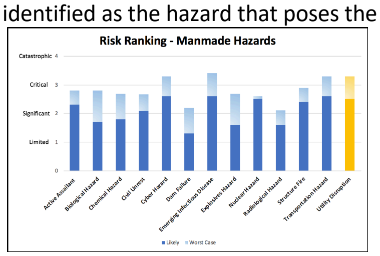
Setting Priorities

This section describes how to use the HIRA to set emergency preparedness priorities.

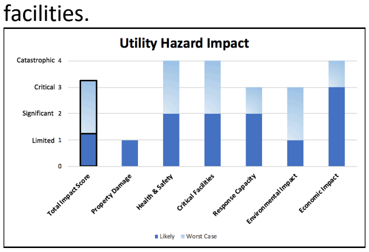
Emergency preparedness priorities are frequently determined based on gut feelings and an unwillingness to deviate from the way things have been done in the past. History has made it abundantly clear that the scariest or most talked-about hazards are not always the hazards that pose the greatest risk to the jurisdiction. It is essential that emergency preparedness decisions are made based on data whenever possible. The HIRA provides a scientifically defensible foundation for preparedness decision making.

Example: Using the HIRA to prioritize preparedness activities.

> The agency has dedicated preparedness efforts to mitigate the risk of Utility Disruption hazards. Utility Disruption hazards were identified as the hazard that poses the highest risk to Howard County by the HIRA.



> The HIRA anticipates the property damage and environmental impact of a Utility Disruption hazard to be limited, so preparedness efforts will concentrate on mitigating risk to the economy, health and safety, response capacity, and critical facilities.



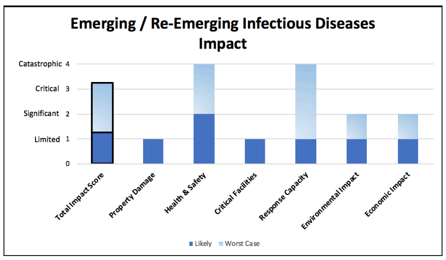
Justifying Existing Plans

This section describes how to use the HIRA to provide justification for existing preparedness plans.

Many preparedness priorities are based on years of experience but lack the hard data to support what decision makers already know to be true. The information contained in the HIRA can be used to provide a solidly defensible foundation for any number of existing planning decisions.

Example: Using the HIRA to justify existing plans.

The agency has long invested significant resources into disease pandemic preparedness. Although Emerging / Re-Emerging Infectious Disease hazards are not the highest in overall risk to our community, the Health and Safety impact from an Emerging / Re-Emerging Infectious Disease hazard is expected to be higher than some of other hazards addressed in the HIRA. Furthermore, the anticipated impact to Response Capacity is considered catastrophic, and the actions we have taken over the past 10 years will work to ensure a robust health care response.



Evaluating Prevention, Protection, and Mitigation Actions

This section describes how to use the HIRA to evaluate risk management activities.

Risk management is the process of controlling risk by changing the likelihood or expected consequences from any given hazard. Prevention, protection, and mitigation activities are all approaches to managing risk. The HIRA assigns a risk score to every hazard that incorporates that hazard's likelihood of occurrence and expected consequence. An effective risk management action should reference the likelihood and/or consequence of the hazard, as illustrated by the HIRA, and demonstrate how the proposed action will reduce the future likelihood and/or the expected consequence of the hazard. A proposed action that does not reduce the likelihood or the consequence of the hazard and is not an effective risk management solution.

Example: Using the HIRA to evaluate risk management actions.

The agency needs to evaluate three proposals for managing the risk of a Radiological hazard.

- Option A proposes to purchase radiation-resistant uniforms for employees at public facilities.
- Option B proposes to purchase a new system that helps Emergency Medical Services (EMS) and hospitals manage high-casualty incidents.
- Option C proposes to increase the law enforcement presence in public facilities.

Option A does not effectively reduce hazard risk. When describing the consequences of a Radiological Hazard, the HIRA explains that most health and safety impacts result from the traditional explosives used in the attack. The low level of radiation present in most Radiological Hazards will cause fear but will not significantly impact health and safety. Option A does not reduce likelihood or consequence.

Option B effectively reduces hazard risk by reducing the consequence of a Radiological Hazard. Mass casualty systems can reduce two of the key impact areas identified by the HIRA (response capacity and health and safety). Option B will also reduce the consequence of other hazard types.

Option C effectively reduces hazard risk by reducing the likelihood of a Radiological Hazard. Police presence can reduce the future likelihood of attack.

Responding to an Emergency

This section describes how to use the HIRA anticipate challenges during an emergency event.

During an emergency, planning decisions made in seconds have consequences that last lifetimes. It may take hours or days for planning teams to access the data they need to make educated response decisions. Although experienced emergency managers can quickly identify planning priorities, it is possible that some issues may remain unaddressed it. The HIRA Consequence Analysis provides an easy-to-understand overview of the expected consequences during an emergency-level hazard event.

Example: Using the HIRA as a planning tool during an emergency event.

> *Emergency Manager:* "The flu pandemic is getting worse. We've increased support for the Health Department and Hospitals. Is there anything else we should be worried about?"
>
> *Emergency Operations Center (EOC) Tech:* "The HIRA identified that staffing may become a concern at response agencies and critical facilities if enough of their staff becomes sick."
>
> *Emergency Manager:* "Great catch. Contact Police, Fire, and DPW Utilities and see what we can do to support their staffing needs."

<u>SECTION 4</u>

PLANNING PROCESS

Planning Process

Contents of this Section

I. PLANNING OVERVIEW

This section discusses the guidance and strategic goals that influenced the planning process.

The HIRA combines best practice guidance with local stakeholder expertise to create a hazard identification and risk assessment that meets or exceeds industry standards while remaining relevant and specific to the Howard County context.

The HIRA and the accompanying quick-reference sheets were developed to support the emergency preparedness efforts of all Howard County government agencies, private-sector stakeholders, and the public. The HIRA is a foundational document and was developed to satisfy the needs of many Howard County planning and policy initiatives. Howard County initiatives that will build upon this foundation include but are not limited to:

- The Howard County Comprehensive Emergency Response and Recovery Plan (CERRP)
- Hazard-Specific Annexes to the CERRP
- The Howard County Office of Emergency Management Strategic Plan
- The Multi-Year Training and Exercise Plan (MYTEP)
- Natural Hazards Mitigation Plan (NHMP)
    - Flood Hazard Mitigation Plan-Annex (FMP)
    - Manmade and Technological Hazards Plan-Annex (MTHMP)
    - Historical and Cultural Resources Plan-Annex (HCRP)
- Emergency Management Accreditation Program (EMAP) Accreditation

Guidance from literature, industry accreditation standards, and model programs were essential to the development of the HIRA. Various Federal documents, such as, *Understanding Your Risk: Identifying Hazards and Estimating Losses,*[1] *Local Mitigation Planning Handbook*[2] *(44 CFR 201.6),* and *Integrating*

[1] *Understanding Your Risks: Identifying Hazards and Estimating Losses,* FEMA. Available at https://www.fema.gov/media-library/assets/documents/4241 (last accessed November 26, 2019).
[2] *Local Mitigation Planning Handbook,* FEMA, Available at http://www.fema.gov/media-library-data/20130726-1910-25045-9160/fema_local_mitigation_handbook.pdf (last accessed November 26, 2019).

Manmade Hazards Into Mitigation Planning[3] provided Federal insight into the risk assessment process. The HIRA was developed to meet all risk assessment recommendations of the EMAP.[4] EMAP Standard 4.3 provides important guidance on Hazard Identification, Risk Assessment, and Consequence Analysis. This standard states that an Emergency Management Program should use a broad range of sources to identify the natural and human-caused hazards that potentially impact the jurisdiction. Standard 4.3 also states that a risk assessment and consequence analysis should consider the impact on the public, responders, continuity of operations, property, facilities and infrastructure, the environment, the economic condition of the jurisdiction, and the public's confidence in the jurisdiction's government.

[3] *Integrating Manmade Hazards Into Mitigation Planning,* FEMA. Available at http://www.fema.gov/media-library/assets/documents/4528 (last accessed November 26, 2019).
[4] *Emergency Management Standard,* Emergency Management Accreditation Program. Available at https://emap.org/index.php/program-resources/steps-to-accreditation (last accessed November 26, 2019).

II. PLANNING PROCESS

This section discusses the steps that were essential to the completion of the HIRA.

The HIRA project was completed in five phases. The phases of the HIRA project and the associated objectives are as follows:

Planning Phase	Key Objectives
Phase I	Assemble a multidisciplinary Steering Committee to: ▪ Create and validate the list of hazards to be addressed ▪ Identify components for consequence analysis ▪ Create and validate the Howard County Risk Tool ▪ Identify Subject Matter Experts for scenario development and consequence analysis
Phase II	Work with the Scenario Development Experts to: ▪ Develop hazard scenarios to guide consequence analysis
Phase III	Work with Subject Matter Experts to: ▪ Conduct a hazard-specific consequence analysis that includes warning time, duration, impact to property, impact to life and health, impact to critical facilities, impact to response capacity, impact to the environment, and impact to the economy ▪ Establish the historical likelihood of each hazard based on local occurrence Conduct a Community Survey on Hazards to: ▪ Evaluate public confidence in government response, confidence in personal preparedness, and perceived impact to standard of living/quality of life
Phase IV	Conduct a Subject Matter Expert Workshop to: ▪ Review and validate the results of the consequence analysis ▪ Validate total consequence scores ▪ Assign future likelihood scores based on historical likelihood and future trends
Phase V	Assemble the Steering Committee to: ▪ Review and validate the final risk assessment results

** Please note, the scores for the various hazards were submitted by our subject matter experts in August 2019. In light of the Covid-19 pandemic and nationwide civil unrest spanning from March 2020 to present at the time of this publishing (July 2020), subject matter experts were asked to incorporate additional feedback or update scores if applicable. These updates were incorporated into the 2019 version. The HIRA will be updated annually for these scores in order to provide the most accurate data for Howard County.*

III. PLANNING PARTNERS

This section identifies key stakeholders and their roles in the development and completion of the HIRA.

The development of the HIRA involved extensive support from traditional response organizations, government agencies, private-sector partners, and engaged members of the public. Partners in the development of the HIRA can be broken into six groups:

- HIRA Planning Work Group
- HIRA Steering Committee
- Scenario Development Experts
- Subject Matter Experts
- Engaged Public Partners
- Other Supporting Partners

Although several agencies and individuals supported the HIRA project at multiple levels, the organization and function of each group was unique.

HIRA Planning Work Group: The Planning Work Group was responsible for the development and management of the HIRA project from inception to completion. The Planning Work Group drafted all HIRA documents, managed all HIRA data, facilitated meetings, and coordinated the involvement of all HIRA stakeholders. The Planning Work Group was comprised of staff from the Howard County OEM.

HIRA Steering Committee: The HIRA Steering Committee provided strategic guidance and support throughout the HIRA project. The Steering Committee was responsible for reviewing and validating all materials and processes developed by the Planning Work Group. The Steering Committee played an essential role in the identification and selection of Scenario Development Experts and local Subject Matter Experts.

Scenario Development Experts: Scenario Development Experts were selected by the Steering Committee for their expertise in one or more of the hazard categories. Using their expertise and understanding of the local context, the Scenario Development Experts created likely and worst-case scenarios for each of the 23 hazards addressed by the HIRA.

Subject Matter Experts: Subject Matter Experts were selected by the Steering Committee for their expertise in one or more of the subject areas included in the consequence analysis and risk assessment. The multidisciplinary team of Subject Matter Experts was composed of community experts with diverse backgrounds and areas of expertise. Subject Matter Experts used the likely and worst-case hazard scenarios as guides to calculate the anticipated impacts in each of the major consequence areas. At the end of the data collection period, the Subject Matter Expert Workshop brought many experts together to interpret our findings and attempt to build consensus on several of the more subjective components of the risk assessment.

Engaged Public Partners: Public involvement was a key component of the HIRA process. Howard County citizens were invited to participate in the process through the Community Survey on Hazards. In total, 160 members of the public provided information to support the analysis of public confidence and hazard perception.

Other Supporting Partners: Throughout the HIRA project, the Planning Work Group received support from technical experts, industry professionals, and other community stakeholders. The other supporting partners provided essential guidance during the project's development and review.

HIRA Planning Work Group	
Organization	**Representative**
Howard County Office of Emergency Management	Nicole Regino
	Michael Hinson
	Katie Canady
	Maria Bernadzikowski
	Chris Meyer
	Tiffany Smith
	Samantha Durbin

HIRA Steering Committee	
Organization	**Representative**
Columbia Association	Nick Mooneyhan
Howard County Administration	Janssen Evelyn
	Mark S. Miller
	Scott Peterson
Howard County Department of Community Resources and Services	Jacqueline R. Scott
	Daniel Kershner
	Cheryl Mattis
Howard County Department of Fire and Rescue Services	Stephen Hardesty
Howard County Department of Inspection, Licenses, and Permits	Bob Frances
	Bob Firmani
	Don Mock
Howard County Department of Public Works	Kris Singleton
Howard County Department of Technology and Communication Services	Glenn Hansen
	David Dulong
	Rob Slivinski
	Wynne Hayes
	James Cox
Howard County Health Department	Shelia Palmiotto
	Giselle Bonilla
	Lauren Williams
Howard County Office of Emergency Management	Maria Bernadzikowski
	Katie Canady
	Michael Hinson

HIRA Steering Committee	
Organization	**Representative**
	Chris Meyer
	Nicole Regino
	Tiffany Smith
	Samantha Durbin
Howard County Police Department	Kelly Tibbs
	Rocco Sovero
	William Cheuvront
Howard County Risk Management	Amy Lanham
Johns Hopkins Applied Physics Laboratory	John Contestabile

Scenario Development Experts		
Organization	**Representative(s)**	**Hazard Specialization**
Howard County Department of Fire and Rescue Services	• Stephen Hardesty	• Chemical Hazard • Biological Hazard • Explosives Hazard • Nuclear Blast • Radiological Hazard • Structure Fire • Transportation Hazard • Wildfire
Howard County Department of Public Works	• Ross Beschner • Arthur Shapiro	• Utility Disruption
Howard County Department of Public Works	• Mark Richmond	• Dam Failure • Flood
Howard County Department of Public Works	• Krishnakanth Jagarapu • Arthur Shapiro	• Transportation Hazard
Howard County Department of Technology and Communication Services	• Glenn Hansen • Gary Shives • Rob Slivinski • David Dulong	• Cyber Hazard
Howard County Health Department	• Giselle Bonilla • Bert Nixon	• Biological Hazard • Emerging Infectious Diseases • Pest Infestation / Zoonotic Infection • Utility Disruption

Scenario Development Experts		
Organization	**Representative(s)**	**Hazard Specialization**
Howard County Office of Emergency Management	• Maria Bernadzikowski • Chris Meyer • Michael Hinson • Tiffany Smith	• Drought • Earthquake • Hurricane / Tropical Cyclone • Lightning • Severe Winter Storm
Howard County Police Department	• William Cheuvront	• Active Assailant • Biological Hazard • Chemical Hazard • Civil Unrest • Explosives Hazard • Nuclear Blast • Radiological Hazard
National Oceanic and Atmospheric Administration	• Shawn Dahl	• Solar Storm
National Oceanic and Atmospheric Administration	• Christopher Strong	• Tornado/Wind Storm

Subject Matter Experts		
Organization	**Representative(s)**	**Area of Expertise**
Baltimore Gas and Electric	• Megan Eaves	• Critical Facilities
Colonial Pipelines	• Frank Gallo	• Critical Facilities
Community Foundation of Howard County	• Julie McIntyre • Beverly White-Seals	• Response Capacity
CSX	• Mike Austin	• Health and Safety • Response Capacity
First Energy	• Dave Kline	• Critical Facilities
Howard County Community Organizations Active in Disaster	• Katie Canady	• Response Capacity
Howard County Department of Community Resources and Services	• Michelle Henry • Daniel Kershner	• Health and Safety • Response Capacity

Subject Matter Experts		
Organization	**Representative(s)**	**Area of Expertise**
Howard County Department of Fire and Rescue Services	• Stephen Hardesty	• Health and Safety • Response Capacity
Howard County Department of Inspection, Licenses, and Permits	• Bob Firmani • Bob Frances • Don Mock	• Property Damage
Howard County Department of Planning and Zoning	• Beth Burgess • Peter Conrad	• Environmental Impact
Howard County Department of Public Works	• Mark Richmond • Arthur Shapiro • Cadijah Walcott	• Critical Facilities • Environmental Impact • Property Damage
Howard County Department of Public Works	• Krishnakanth Jagarapu	• Health and Safety • Response Capacity
Howard County Department of Technology and Communications Services	• Glenn Hansen • Gary Shives	• Critical Facilities
Howard County Economic Development Authority	• Larry Twele	• Economic Impact
Howard County Health Department	• Giselle Bonilla • Elizabeth Menachery • Bert Nixon • Andrea Raid • Amy Skaggs • Lauren Williams	• Health and Safety • Response Capacity • Environmental Impact
Howard County Hospital System	• Gene Mellin	• Health and Safety • Response Capacity
Howard County Office of Emergency Management	• Michael Hinson • Chris Meyer • Maria Bernadzikowski • Katie Canady • Tiffany Smith • Samantha Durbin	• Response Capacity
Howard County Recreation and Parks	• Shawnte Berry	• Environmental Impact
Howard County Police Department	• William Cheuvront • Rocco Sovero	• Response Capacity

Subject Matter Experts		
Organization	**Representative(s)**	**Area of Expertise**
Maryland Transportation Authority	• TJ Bathras	• Health and Safety • Response Capacity
Regional Economic Studies Institute, Towson University	• Daraius Irani	• Economic Impact
Regional Transportation Authority (RTA)	• Andrew Johnson	• Health and Safety • Response Capacity
State Highway Administration	• Jim Jones	• Health and Safety • Response Capacity
Williams Gas Pipeline	• Tim Rich	• Critical Facilities

Other Supporting Partners		
Organization	**Representative(s)**	**Support Area**
Howard County Administration	• Mark Miller	• Public Information
Howard County Bureau of Utilities	• Bruce Taylor	• Provided data on generators and utilities
Howard County Department of Fire and Rescue Services	• Jeremy Clancy	• Provided data on Chemical Hazards within Howard County
Howard County Department of Fire and Rescue Services	• Maria Hogg	• Public Information
Howard County Department of Fire and Rescue Services	• Kevin Panizari	• Provided data on Tier II facilities and data on Chemical Hazards within Howard County
Howard County Department of Planning and Zoning	• James Wilkerson	• Created Tropical Storm Maps for Howard County
Howard County Department of Technology and Communications Services	• John Bussiere	• Geographic Information System

Other Supporting Partners		
Organization	**Representative(s)**	**Support Area**
Howard County Department of Technology and Communications Services	• Rob Slivinsky	• Geographic Information System
Howard County Storm Water Management	• Avinash Dewani	• Provided data on Dams within Howard County
John Hopkins Applied Physics Laboratory	• Mark Gabriele	• Risk Calculation
John Hopkins Applied Physics Laboratory	• Chris Gifford	• Risk Calculation
John Hopkins Applied Physics Laboratory	• Richard Waddell	• Risk Calculation
Little Patuxent Water Reclamation Plant	• Robert Hindt	• Provided data on the Little Patuxent Water Reclamation Plant
National Weather Service	• Michael Muccilli	• Provided data on tropical cyclones in Howard County
Sage Policy Group, Inc.	• Anirban Basu	• Economic Analysis

SECTION 5
INTERPRETING THE HAZARD PROFILES

Interpreting the Hazard Profiles

Contents of this Section

Guidance for interpreting HIRA hazard profiles:

The information contained within the HIRA hazard profiles is intended to be interpreted and used for a wide variety of emergency preparedness and planning efforts. Profile organization is consistent among all hazard profiles to allow for easy comparison between hazards. The information and analysis contained in the hazard profiles comes from many distinct sources including published literature, unpublished internal documents, Subject Matter Expert consultation, and independent calculation. This section is a detailed guide to the interpretation of the hazard profiles.

There are 13 manmade hazards and 10 natural hazards profiled by the HIRA. Each of the hazard profiles included in the HIRA is organized into the following sections and sub-sections:

V. OVERVIEW
- Definition
- Risk Profile
- Risk Matrix
- Risk Ranking

VI. HAZARD CHARACTERISTICS
- Description of the Hazard
- Local Context

VII. LIKELIHOOD ANALYSIS
- Occurrence of the Hazard
- Future Likelihood of the Hazard

VIII. CONSEQUENCE ANALYSIS
- Consequence Analysis Overview
- Consequence Analysis: Likely Hazard Scenario
- Consequence Analysis: Worst-Case Hazard Scenario
- Consequence Analysis: Public Perception

I. OVERVIEW GUIDE

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

The definition section contains a concise definition of the hazard. This section establishes the official characterization of the hazard for use in all subsequent Howard County planning and policy efforts. There is a lack of consistent guidance for categorizing and defining hazards, but the hazard definitions contained in the HIRA seek to reflect Federal and state guidance whenever possible. All definitions included in the HIRA were selected and approved by the HIRA Steering Committee.

Risk Profile

The Risk Profile section contains the completed risk table specific to the profiled hazard as established by the Howard County Risk Tool. The below table is a sample of tables which will characterize the Likelihood, Consequence, and Risk of the hazard in numerical terms.

Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	2.75 Infrequent-Likely		50%
CONSEQUENCE	**Impact**	1.8 Limited-Significant	3 Critical	40%
	Warning Time	4 Short	4 Short	5%
	Duration	1 Short	1 Short	5%
TOTAL RISK SCORE		**2.3**	**2.8**	

The risk assessment for each hazard is based off of a Likely and a Worst-Case scenario for that specific hazard category. Likely and Worst-Case scenarios were developed by the HIRA Scenario Development Expert team.

- Likely Hazard Scenario refers to the emergency-level hazard scenario that is most likely to occur within the jurisdiction. An emergency-level hazard is any hazard that requires a response from at least two agencies.
- Worst-Case Hazard Scenario refers to the worst hazard scenario that could reasonably occur within the jurisdiction.

The Likelihood of hazard occurrence is characterized by the row labeled Likelihood.

- The Likelihood score was determined by the HIRA Subject Matter Expert teams. Expert teams analyzed historical occurrence data and future trends to assign each hazard an annual probability of future hazard occurrence. This probability was translated into a numerical score as outlined by the Risk Tool.

- The Likelihood score reflects the likelihood of occurrence of any emergency-level hazard in the given category and does not differentiate between Likely and Worst-Case scenarios.

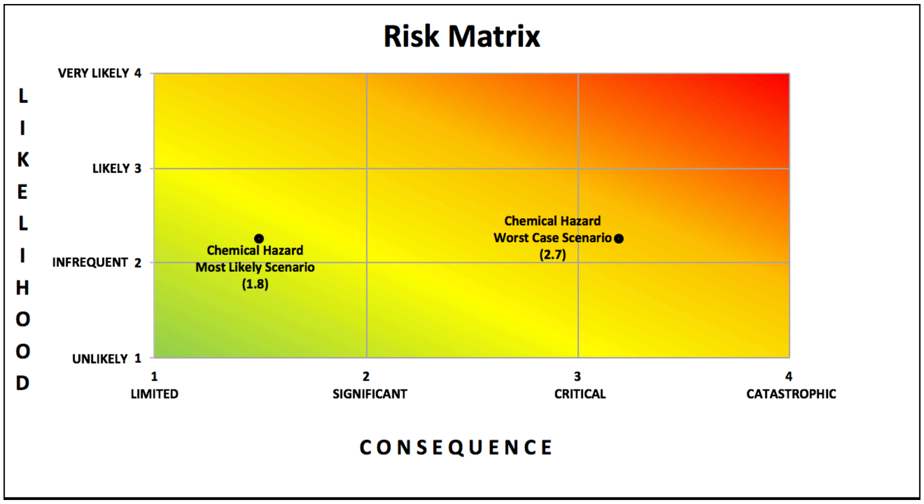
The Hazard Consequence is characterized by the rows labeled Impact, Warning Time, and Duration.

- The Impact score was determined by the Consequence Analysis and Subject Matter Expert teams. Expert teams considered Consequence Analysis data and Risk Tool specifications to assign each hazard a Total Impact Score.
- The Warning Time score was assigned by Subject Matter Experts using Risk Tool specifications.
- The Duration score was assigned by Subject Matter Experts using Risk Tool specifications.

The Total Risk Score for each hazard was calculated as specified in the Risk Tool. Scores for Likelihood, Impact, Warning Time, and Duration were multiplied by their associated weighting factor and summed.

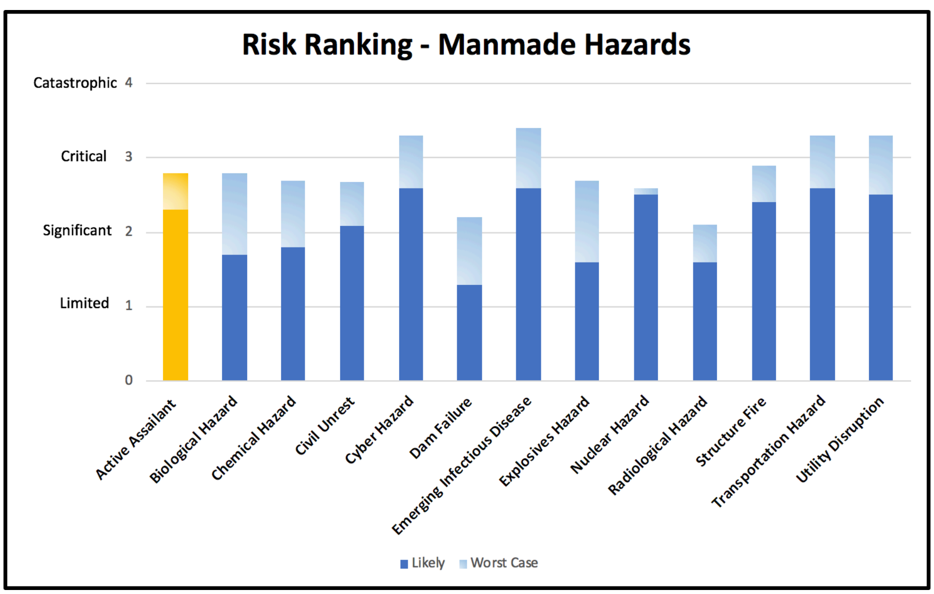
Risk Matrix

The Risk Matrix section contains a graphical illustration of the hazard and its associated Likely and Worst-Case risk. The Risk Matrix demonstrates Likelihood on the graph's Y-axis and Consequence on the graph's X-axis. The risk score of the hazard is included below the label of each hazard.



Risk Ranking

The Risk Ranking section contains a graphical representation of the Likely and Worst-Case risk scores for each hazard. The hazards are organized from highest risk to lowest risk based on Likely risk score. Worst-Case risk score is demonstrated by a light-blue extension above each risk bar. Where no Worst-Case bar is visible, Worst-Case risk is equivalent to Likely risk. The risk rankings are divided by natural and manmade hazards. The subject of the hazard profile is in gold.



II. HAZARD CHARACTERISTICS GUIDE

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

The Description of the Hazard section further elaborates on the concise hazard characterization provided in the initial definition. Some hazards are broken up into subcategories. This occurs when there is one hazard, such as flooding, that can be broken into a subcategory, such as flash flooding. Hazard incidents are discussed when there is an occurrence of the hazard or subcategory of the hazard. This section derives information from many sources including published literature, Federal guidance, and Subject Matter Expert consultation. Information in this section is specific to the hazard and is not specific to Howard County.

Local Context

The Local Context section factors specific to Howard County that may impact local risk from a specific hazard. This section may include factors specific to Howard County that affect the likelihood of a hazard's occurrence within the planning area. This section may also include locations, features, or population factors that affect Howard County's vulnerability to the hazard.

III. LIKELIHOOD ANALYSIS GUIDE

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the documented occurrence of the hazard inside the planning area during the reviewed time period. Historical Occurrence information comes from internal records and Subject Matter Expert consultation. The reviewed time period reflects the availability of reliable hazard occurrence data in the jurisdiction.

The Notable Incidents sub-section also contains brief profiles of typical or notable occurrences of the hazard in the jurisdiction.

Future Likelihood of the Hazard for Howard County

The Future Likelihood Table outlines the historical and future likelihood of the hazard occurrence inside the planning area.

Future Likelihood of a Hazard in Howard County	
Historical Average (time period)	1 event every 50 years (1964-2019)
Historical Annual Probability	2% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	1-30% chance of annual occurrence.
Future Likelihood Score	2.75 (Infrequent- Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

- Historical Average is calculated based on the Historical Occurrence profiled in the Occurrence of the Hazard section.
- Historical Annual Probability is calculated based on the Historical Average.
- Future Likelihood expectations and Future Annual Probability are decided by Subject Matter Experts through analysis of historical occurrence data and future trends.
- Future Likelihood Score was derived from the Future Annual Probability as outlined by the Risk Tool.
- Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.

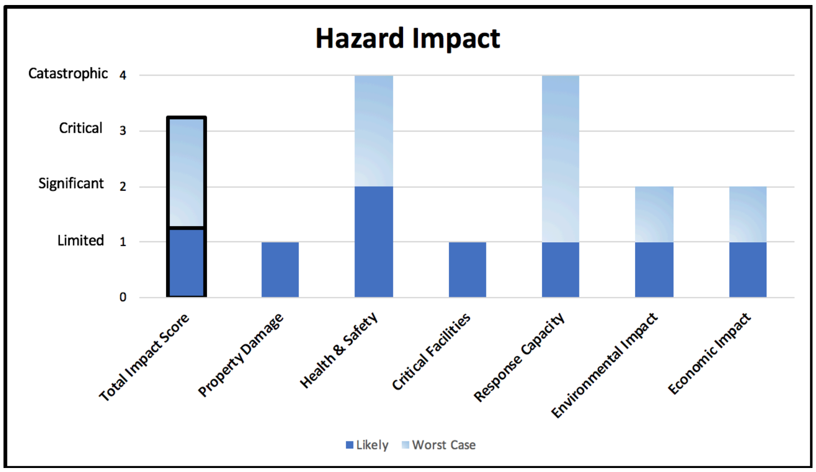
The Considerations sub-section elaborates on the information contained in the Future Likelihood Table. If the future likelihood of hazard occurrence is expected to deviate from historical trends, the factors involved are elaborated in this sub-section. Information in the Considerations sub-section was derived from Subject Matter Expert analysis of historical occurrence and future data trends.

IV. CONSEQUENCE ANALYSIS GUIDE

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Overview

The Consequence Analysis Overview section contains a graphical representation of the hazard's anticipated impact to property, health and safety, critical facilities, response capacity, the environment, and the local economy.



- The Total Impact Score was determined by Subject Matter Expert teams through extensive consideration of Consequence Analysis data and specifications outlined in the Risk Tool.
- The Impact score for each consequence sub-category was derived from the Consequence Analysis using specifications outlined in the Risk Tool.
- Worst-Case impact score is demonstrated by a light-blue extension above each impact bar. Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

The Warning Time and Duration Table provides additional detail on the anticipated duration of the hazard and the expected warning time prior to hazard onset.

Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time prior to an attack.	*Short.* No warning time prior to an attack.
DURATION	*Short.* Initial hazard will likely last less than 20 minutes. It may take up to four hours to declare the hazard location safe.	*Short.* Initial hazard will likely last from 30 minutes to four hours. It may take up to 48 hours to remove the hazard and stabilize all people exposed to the hazardous agent.

- Warning Time refers to the time of awareness prior to the onset of the hazard.
- Duration refers to the time from the onset of the hazard to the point when the hazard ceases to threaten life, property, critical facilities, response capacity, the environment, or the economy.
- Warning Time and Duration are assigned descriptive levels to coincide with the associate score as specified in the Risk Tool.

Consequence Analysis: Likely and Worst-Case Hazard Scenarios

The Consequence Analysis section provides a detailed description of the hazard's anticipated impact to property, health and safety, critical facilities, response capacity, the environment, and the local economy. Each consequence sub-category is assigned a descriptive level to coincide with the associated score as specified in the Risk Tool. The information contained in the Consequence Analysis reflects the data and experience of Subject Matter Experts in each respective field.

Consequence Analysis Likely		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure.
HEALTH and SAFETY	*Limited*	▪ Zero deaths likely. ▪ 20 injuries likely
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. ▪ *Transportation* – Traffic delays for less than one day.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Mutual aid needed. No great impact to response capability. ▪ *Fire and Rescue* – Moderate need for state or Federal assistance. ▪ *Health* – Local resources adequate. Health Department operations will not be affected. ▪ *Hospitals* – Local resources adequate. No impact on the hospital system. ▪ *Emergency Management* – Local resources adequate.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited to no environmental impact. Less than a day of clean-up.
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. ▪ Temporary business disruption in the area of the attack. Damage to image possible.
TOTAL IMPACT[1]	***Limited -***	▪ **Total Impact Score: 1 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

- **Property Damage** details the anticipated percentage of Howard County critical and non-critical infrastructure that will suffer damage from the hazard and the type of damage that is expected.
- **Health and Safety** details the number of deaths and injuries that are expected to result from the hazard and the types of deaths and injuries that are expected.
- **Critical Facilities** details the expected shutdown duration of essential functions. Utilities, Information/Communication, and Transportation are each assigned a descriptive level to coincide with the associated score as specified in the Risk Tool.
- **Response Capacity** details the expected shutdown duration of essential response functions. Police, Fire and Rescue, Health, Hospitals, and Emergency Management are each assigned a descriptive level to coincide with the associated score as specified in the Risk Tool.
- **Environmental Impact** details the hazard's expected impact to the environment.
- **Economic Impact** details the hazard's impact to the economy of Howard County. Loss of economic output and job loss refer only to the hazard's anticipated effect on the gross domestic product of the jurisdiction as calculated by Subject Matter Expert analysis.

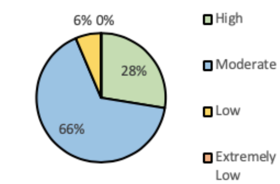
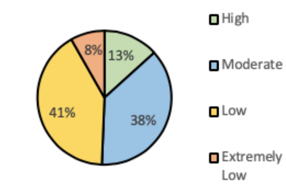
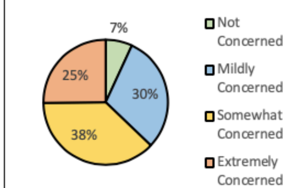
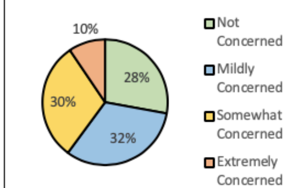
[1] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Information in this section does not include the costs associated with cleanup or healthcare for those affected.

- **The Total Impact Score** was determined by Subject Matter Expert teams through extensive consideration of Consequence Analysis data and specifications outlined in the Risk Tool.

Public Perception

The Public Perception section elaborates on the public's confidence and perceptions of consequence as they relate to each hazard category. The associated table illustrates the public response to the questions posed by the Community Survey on Hazards.

Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
			
Average: 3.21 Moderate - High	*Average: 2.56 Low - Moderate*	*Average: 2.81 Mildly Concerned - Somewhat Concerned*	*Average: 2.22 Mildly Concerned - Somewhat Concerned*

The associated table illustrates the public response to the following questions posed by the Community Survey on Hazards:

- Q1: "Please rate your confidence in Howard County's ability to respond to and recover from this hazard."
- Q2: "Please rate your confidence in your own ability to protect yourself and your family from this hazard."
- Q3: "How concerned would you be for the physical safety of yourself and your loved ones if this hazard event were to occur in Howard County? (assume that you are in the County but not in the immediate hazard area)."
- Q4: "How concerned would you be for your ability to maintain your current standard of living and quality of life if this hazard event were to occur in Howard County? (assume that you are in the County but not in the immediate hazard area)."

V. HIRA PLANNING ASSUMPTIONS

This section details the strategic assumptions made during the development of the HIRA.

It is important to understand the assumptions made by the Howard County HIRA. Assumptions are pieces of information that are assumed to be true in order to draw conclusions from the available data. If an assumption is in doubt or proves to be inaccurate, the conclusions based on this assumption may also be incorrect. Prior to interpreting the information in the HIRA, it is important to review the planning assumptions to assure its continued validity.

- *The HIRA assumes that the likelihood and expected consequences of the included hazards have not changed since the data was collected.*

  Analysis: The HIRA is updated at strategic intervals. However, if there is reason to believe that there have been significant changes to the likelihood or expected consequence of a hazard since the last update, caution should be taken when interpreting the Risk Score.
- *The HIRA assumes that Subject Matter Experts provided accurate insight into their designated area of expertise.*

  Analysis: Great effort was put forth to select a team of local Subject Matter Experts with exceedingly high levels of knowledge, experience, and access to information in their designated areas of expertise. However, if there is reason to believe that information provided by Subject Matter Experts is not accurate, caution should be taken when interpreting all components of the HIRA.
- *The Risk Scores for the Worst-Case hazard scenarios assume that the likelihood of the hazard occurring inside the planning area is equal to the likelihood of the Worst-Case hazard occurring inside the planning area.*

  Analysis: Although data is unavailable for rare events, it is likely that the Worst-Case hazard scenario is far less likely than indicated by the Likelihood score. The Worst-Case scenario is intended primarily to demonstrate the possible severity of the hazard. Caution should be taken when interpreting Worst-Case Risk Scores in the absence of additional data.
- *The Impact score assumes hazards with the highest possible Impact score (4=Catastrophic) are equal.*

  Analysis: A limitation of the Risk Tool is that it is unable to capture differences in Impact among catastrophic events. A hazard event resulting in 50 deaths will receive the same Impact score as a hazard event resulting in 500 deaths. Similarly, a hazard event resulting in 50 deaths will receive the same Impact score as a hazard event with no deaths resulting in catastrophic consequences to property, the environment, and the economy. Caution should be taken when interpreting the Impact score in absence of the full Consequence Analysis.
- *The Public Perception tables assume that the sampled population is representative of the entire population in Howard County.*

  Analysis: The information on Public Perception is intended to be interpreted with caution. Although effort was made to sample outside of traditional government circles, the sample of 160 respondents was not random and may not be representative of the entire population. Caution should be taken when drawing broad conclusions from Public Perception results.

SECTION 6
RISK OVERVIEW

Risk Overview

Contents of this Section

I. HAZARD DEFINITIONS

This section defines the hazard and summarizes the hazard risk profile.

The Howard County HIRA provides a detailed analysis of 13 manmade hazards and 10 natural hazards. Below is a description of each of the hazards addressed in the HIRA:

MANMADE HAZARDS	
Active Assailant: An Active Assailant refers to "an individual actively engaged in killing or attempting to kill people in a confined and populated area. In most cases, active shooters use firearm(s) and have no pattern or method to their selection of victims, which creates an unpredictable and quickly evolving situation that can result in loss of life and injury. Other active shooter attack methods may also include bladed weapons, vehicles, and improvised explosive devices."[1]	**Biological Hazard:** A Biological Hazard can be either intentional or unintentional. An intentional Biological Hazard (Attack) is, "the intentional release of a pathogen (disease causing agent) or biotoxin (poisonous substance produced by a living organism) against humans, plants, or animals. An attack against people could be used to cause illness, death, fear, societal disruption, and economic damage."[2] An unintentional biological hazard can result from the natural spread of infectious disease or from the accidental release of biological agents from health care facilities, research institutions, and industrial operations.
Chemical Hazard: A Chemical Hazard can be either intentional or unintentional. An intentional Chemical Hazard (Attack) is defined as the "spreading of toxic chemicals with the intent to do harm. A wide variety of chemicals could be made, stolen, or otherwise acquired for use in an attack. Industrial chemical plants or the vehicles used to transport chemicals could also be sabotaged."[3] An	**Civil Unrest:** Civil Unrest occurs when public disorder has the potential to cause damage or harm. Civil Unrest is often the result of ideological conflict and may include protests, riots, demonstrations, civil disobedience, and other forms of public obstruction. Not all displays of Civil Unrest are Civil Unrest Hazards. Although many expressions of Civil Unrest are safe and legal, a Civil Unrest

[1] *Active Shooter Attacks Security Awareness for Soft Targets and Crowded Places*, Department of Homeland Security. Available at: https://www.dhs.gov/sites/default/files/publications/Active Shooter Attacks - Security Awareness for ST-CP.PDF (last accessed, June 14th, 2019).

[2] Biological Attack Fact Sheet. (2019, March 13). Retrieved from https://www.dhs.gov/publication/biological-attack-fact-sheet (last accessed October 10, 2019).

3 National Academies and the U.S. Department of Homeland Security. (n.d.). CHEMICAL ATTACK WARFARE AGENTS, INDUSTRIAL CHEMICALS, AND TOXINS. Retrieved from https://www.dhs.gov/sites/default/files/publications/prep_chemical_fact_sheet.pdf (last accessed September 19, 2019).

MANMADE HAZARDS	
Unintentional Chemical Substance Release/Hazmat hazard occurs when a chemical with the potential to cause harm is accidentally released into the environment.	Hazard occurs when the level of public disorder becomes a threat to health, safety, and property.
Cyber Hazard: A Cyber/Communications Infrastructure Hazard is an intentional disruption or manipulation of the information and communication systems used to collect, filter, process, create, and distribute data. An attack of this type may seek to impact data or manipulate data to impact physical infrastructure.	**Dam Failure:** A Dam Failure occurs when some or all of a dam's water-retaining barrier becomes damaged causing the uncontrolled release of water downstream. Dam Failure can lead to rapid flooding of downstream land. A Dam Failure can be the result of a design or construction error, insufficient maintenance, human error, or internal erosion. Dam Failures can also occur as the result of an intentional attack or as a cascading effect of natural hazards such as flooding, earthquakes, or geological instability.
Emerging Infectious Disease: Emerging/Re-emerging Infectious Disease is an infectious disease that has newly appeared in a population or has existed but is rapidly increasing in incidence or geographic range in the near future. Emerging infectious diseases can be caused by previously undetected or unknown infectious agents or pathogens. The hazard can be either an outbreak, cluster, epidemic or pandemic.	**Explosives Hazard:** An Explosives Hazard occurs when an explosive device is intentionally used to cause harm to people, property, operational capacity, or the environment. There are also controlled explosions which are "the deliberate detonation of an explosive device under strictly controlled circumstances".[4] Controlled explosions are often work related.
Nuclear Blast Hazard: A Nuclear Blast Hazard is the result of a device that uses a nuclear reaction to create an explosion far more powerful than that of conventional explosives.[5] When nuclear weapons or improvised nuclear devices (INDs) explode, they give off energy in the form of a blast wave, intense light, heat, and radiation.	**Radiological Hazard:** A Radiological Hazard can be intentional or unintentional. An intentional Radiological Hazard (Attack) occurs when a population is intentionally exposed to radiation through a non-nuclear mechanism (nuclear weapon hazards are profiled separately). A Radiological Attack may take the form of a radiological exposure device (RED) or a radiological dispersal device (also known as a dirty bomb or RDD).[6] An unintentional radiological substance release hazard occurs when radiation is accidentally discharged into the environment. Unintentional radiological substance release may occur as the result of a

[4] Controlled explosion. Retrieved from https://www.dictionary.com/browse/controlled-explosion. (last accessed September 24, 2019).

[5] *More Information on Types of Radiation Emergencies,* CDC. Available at https://www.cdc.gov/nceh/radiation/emergencies/moretypes.htm (last accessed October 4, 2019).

[6] *More Information on Types of Radiation Emergencies,* CDC. Available at https://www.cdc.gov/nceh/radiation/emergencies/moretypes.htm (last accessed September 27, 2019).

MANMADE HAZARDS	
	nuclear power plant accident, a transportation accident, or a workplace incident.[7]
Structure Fire: A Structure Fire is an uncontrolled fire involving a building or structure. Structure fires can occur in a residential, commercial, or industrial setting. Fires can easily spread from one structure to another, and the size of a structure fire hazard is constantly evolving. Structure fire hazards can be caused intentionally or unintentionally, but often the origin of the fire is not known until after the hazard has been brought under control.	**Transportation Hazard:** A Transportation Hazard occurs whenever a vehicle accident or collision has the potential to cause harm. Any vehicle is capable of being involved in a Transportation Hazard. The most common types of Transportation Hazards involve automobiles, trains, airplanes, or boats. A transportation hazard can involve one or multiple vehicles, and cascading effects may include the release of hazardous materials.
Utility Disruption: A Utility Disruption occurs when the disruption of the gas, water, or electrical infrastructure has the potential to cause harm. Utility Disruption hazards can be intentional, unintentional, or occur as a cascading effect of another hazard.	

NATURAL HAZARDS	
Drought: According to the National Oceanic and Atmospheric Administration (NOAA), Drought is a complex phenomenon which is difficult to monitor and define. Drought is the *absence* of water. It is a creeping phenomenon that slowly sneaks up and impacts many sectors of the economy and operates on many different time scales. As a result, the climatological community has defined four types of drought: 1) meteorological drought, 2) hydrological drought, 3) agricultural drought, and 4) socioeconomic drought.[8]	**Earthquake:** An Earthquake is a sudden release of energy from the earth's crust that creates seismic waves. Stress is created in the earth's crust from thermal variations, tectonic changes, and other forms of pressure. Weaknesses in the earth crust yield when the stresses exceed the friction along these crustal weaknesses, and an earthquake happens. At the earth's surface, earthquakes may manifest themselves by a shaking or displacement of the ground.
Flood: A Flood is defined as the accumulation of water that exceeds a physical barrier or collects in a low-lying area that leads to the inundation of an area. Flooding typically results from large scale weather systems that generate prolonged or highly impactful rainfall. Other conditions such as winter snow thaws, over-saturated soil, ice jams	**Hurricanes/Tropical Cyclone:** Hurricanes, tropical storms, and typhoons are collectively known as tropical cyclones. NOAA defines a tropical cyclone as a "warm-core non-frontal synoptic-scale cyclone, originating over tropical or subtropical waters, with organized deep convection and a closed surface wind circulation about a well-

[7] *More Information on Types of Radiation Emergencies,* CDC. Available at https://www.cdc.gov/nceh/radiation/emergencies/moretypes.htm (last accessed September 27, 2019).
[8] Arndt, and Enloe. Definition of Drought. Retrieved from https://www.ncdc.noaa.gov/monitoring-references/dyk/drought-definition (last accessed September 24, 2019).

NATURAL HAZARDS	
breaking apart, and urbanization can cause flooding as well. Flash floods occur when there is a large amount of rainfall in a short duration of time which causes a rapid rise in water level.	defined center. Once formed, a tropical cyclone is maintained by the extraction of heat energy from the ocean at high temperature and heat export at the low temperatures of the upper troposphere."[9]
Lightning: Lightning is a giant spark of electricity in the atmosphere between clouds, the air, or the ground. In the early stages of development, air acts as an insulator between the positive and negative charges in the cloud and between the cloud and the ground. When the opposite charges builds up enough, this insulating capacity of the air breaks down and there is a rapid discharge of electricity that we know as lightning. The flash of lightning temporarily equalizes the charged regions in the atmosphere until the opposite charges build up again.	**Pest Infestation/Zoonotic Infection:** A Pest Infestation is the occurrence of one or more pest species in an area or location where their numbers and impact are currently or potentially at intolerable levels. Zoonotic Diseases (also known as zoonoses) "are caused by infections that spread between animals and people."[10]
Severe Winter Weather: Severe Winter Weather refers to a weather event that produces forms of precipitation caused by cold temperatures, such as snow, sleet, ice, and freezing rain, while ground temperatures are cold enough to cause precipitation to freeze. Windy conditions may also be present during a winter storm.	**Solar Storm**: Solar Storms, also referred to as geomagnetic storms, are "a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding Earth."[11] These storms result from variations in the solar wind that produces major changes in the currents, plasmas, and fields in Earth's magnetosphere.[12] The largest storms that result from these conditions are associated with solar coronal mass ejections (CMEs) where a billion tons or so of plasma from the sun, with its embedded magnetic field, arrives at Earth.[13] CMEs typically take several days to arrive at Earth, but have been observed, for some of the most intense storms, to arrive in as short as 18 hours.[14]
Tornado/Wind Storm: A Tornado is "a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a	**Wildfire:** A Wildfire is an uncontrolled forest fire, grassland fire, rangeland, or urban-interface fire which consumes natural fuels and spread in

[9] *Glossary of National Hurricane Center Terms*, http://www.nhc.noaa.gov/aboutgloss.shtml#TROPCYC (last accessed September 26, 2019).
[10] Zoonotic Diseases | One Health | CDC. (n.d.). Retrieved from https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html (last accessed September 27, 2019).
[11] Dahl, Shawn, NOAA, Space Weather Forecaster (2019).
[12] Space Weather Prediction Center, National Oceanic and Atmospheric Administration, Geomagnetic Storms, (NOAA), www.swpc.noaa.gov/phenomena/geomagneticv-storms (last accessed March 17, 2016)
[13] Dahl, Shawn, NOAA, Space Weather Forecaster (2019).
[14] Space Weather Prediction Center, National Oceanic and Atmospheric Administration, Geomagnetic Storms, (NOAA), www.swpc.noaa.gov/phenomena/geomagneticv-storms (last accessed March 17, 2016)

NATURAL HAZARDS	
funnel cloud."[15] Tornadoes are related to larger vortex formations, and therefore often form in convective cells such as thunderstorms or in the right forward quadrant of a hurricane, far from the hurricane eye.	response to the environment.[16] Wildfires can be either a natural phenomenon or human-caused. The frequency and severity of wildfires depends on both weather and human activity.

** Please note, the scores for the various hazards were submitted by our subject matter experts in August 2019. In light of the Covid-19 pandemic and nationwide civil unrest spanning from March 2020 to present at the time of this publishing (July 2020), subject matter experts were asked to incorporate additional feedback or update scores if applicable. These updates were incorporated into the 2019 version. The HIRA will be updated annually for these scores in order to provide the most accurate data for Howard County.*

II. RISK OVERVIEW CHARTS

The Risk Overview charts compare hazards based on Risk Score, Likelihood, Total Impact, Impact to Property, Impact to Health and Safety, Impact to Critical Facilities, Impact to Response Capacity, Impact to the Environment, and Impact to the Economy.

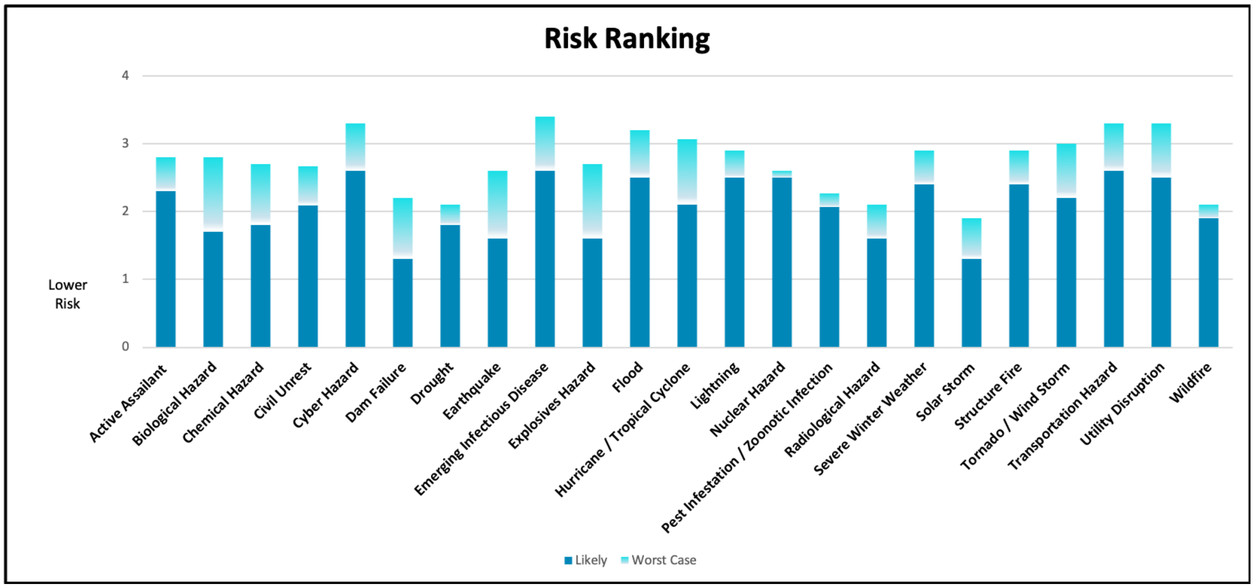
All information is specific to Howard County.

Unless otherwise noted, charts are based on the most likely hazard scenario with the worst-case scenario represented as a shaded extension above each bar.

Risk Ranking

The Risk Ranking lists hazards by total Risk Score. Risk is a function of Likelihood and Consequence. Ranking is from highest risk to lowest risk.

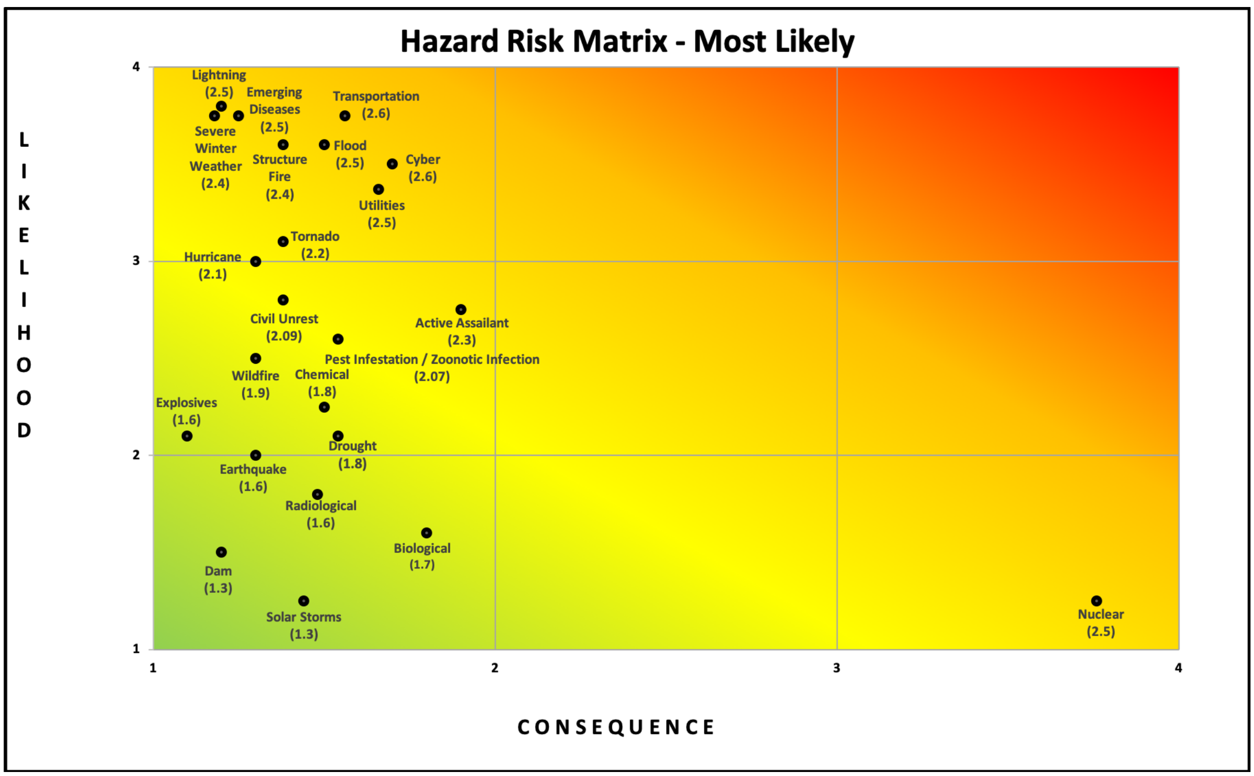
[15] *Glossary of Meteorology*, American Meteorological Society (2000), available at http://www.spc.noaa.gov/faq/tornado/ (last accessed October 1, 2019).
[16] See also *NWCG Glossary of Wildland Fire Terminology*, http://www.nwcg.gov/pms/pubs/glossary/w.htm#Wildfire (last accessed October 1, 2019).

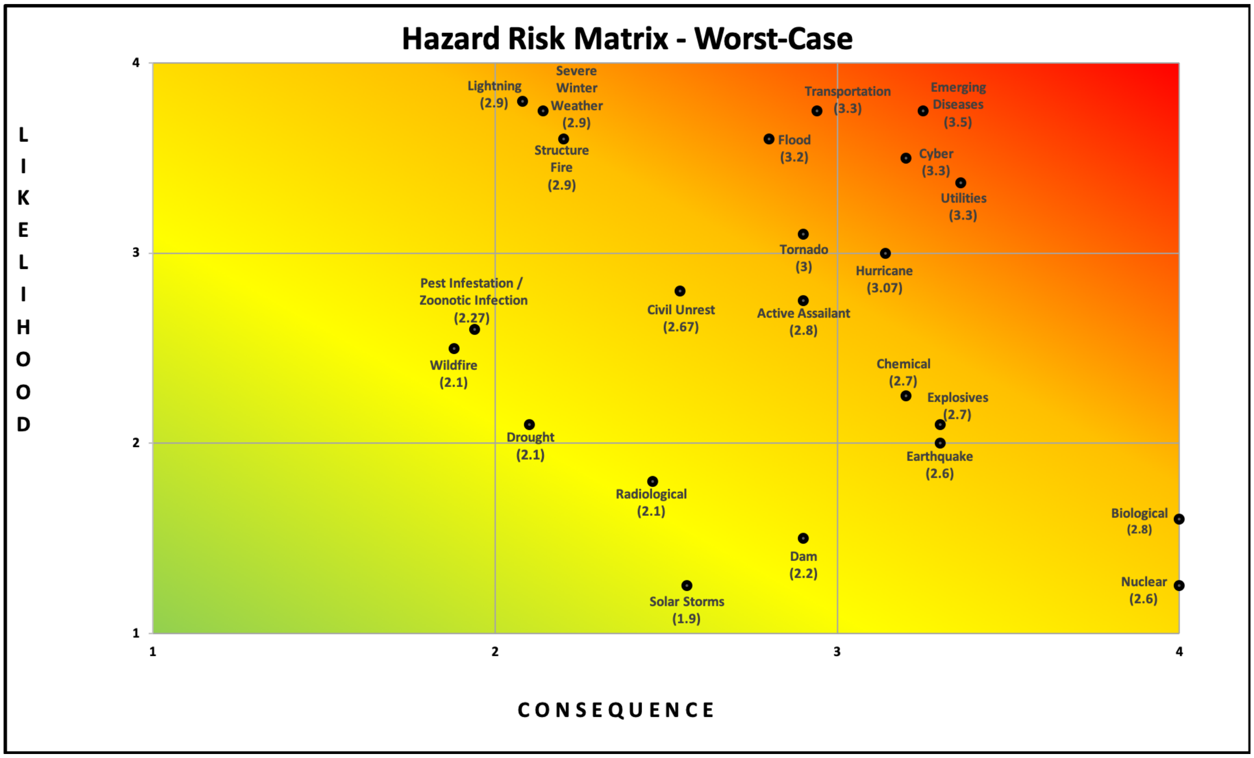


Where no Worst-Case bar is visible, Worst-Case risk is equivalent to Likely risk

Risk Matrix

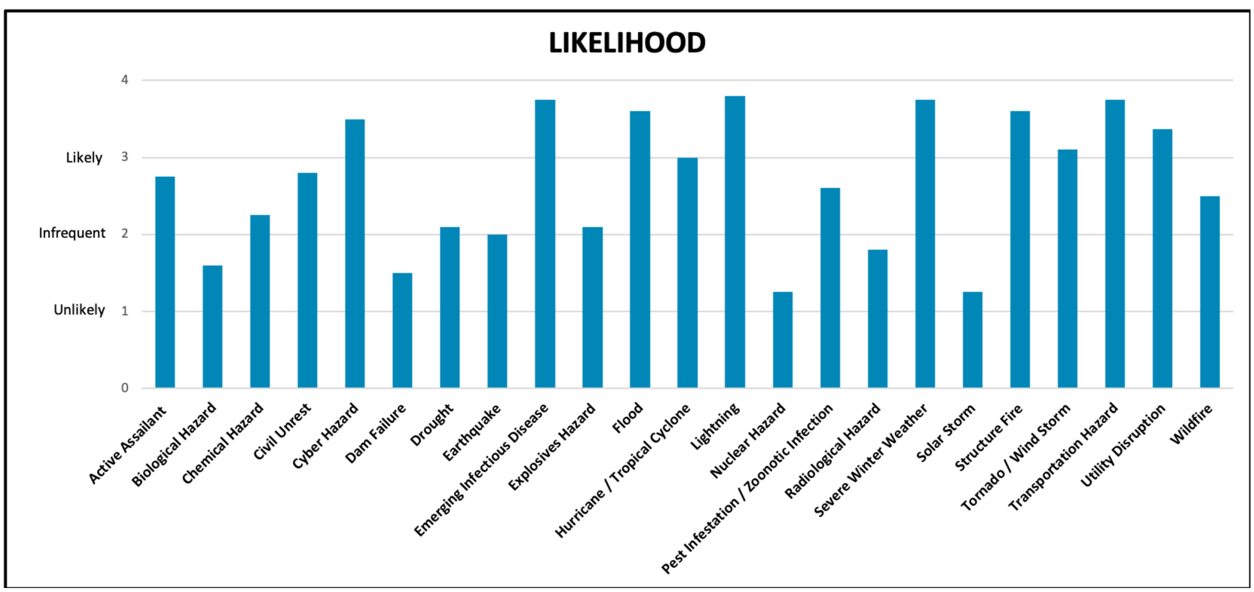
The Risk Matrix illustrates hazard risk graphically by Likelihood and Consequence. Hazards are plotted base on the most likely hazard scenario in the first graph and worst-case scenario in the second graph. Total Risk Score is noted in parentheses for each hazard category.





Likelihood

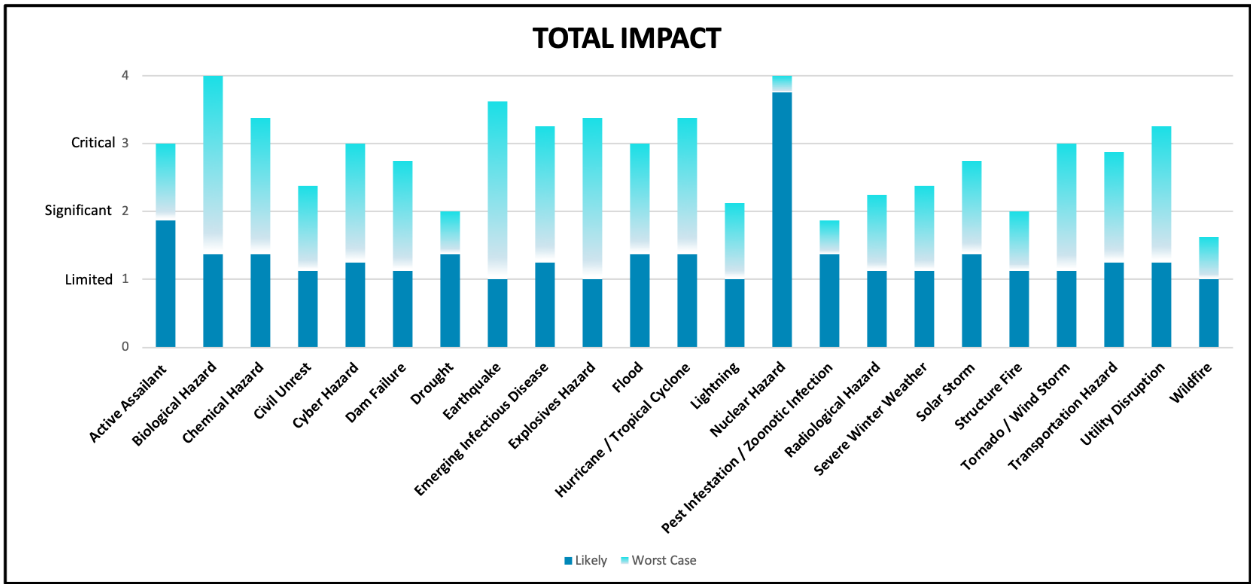
The Likelihood chart lists hazards by the anticipated future annual likelihood of the hazard's occurrence. *Very Likely* = 30+ chance of annual occurrence. *Likely* = 11-30% chance of annual occurrence. *Infrequent* = 1-10% chance of annual occurrence. *Unlikely* = Less than 1% chance of annual occurrence.



The likelihood that a hazard will occur does not differentiate between Likely and Worst-Case.

Total Impact

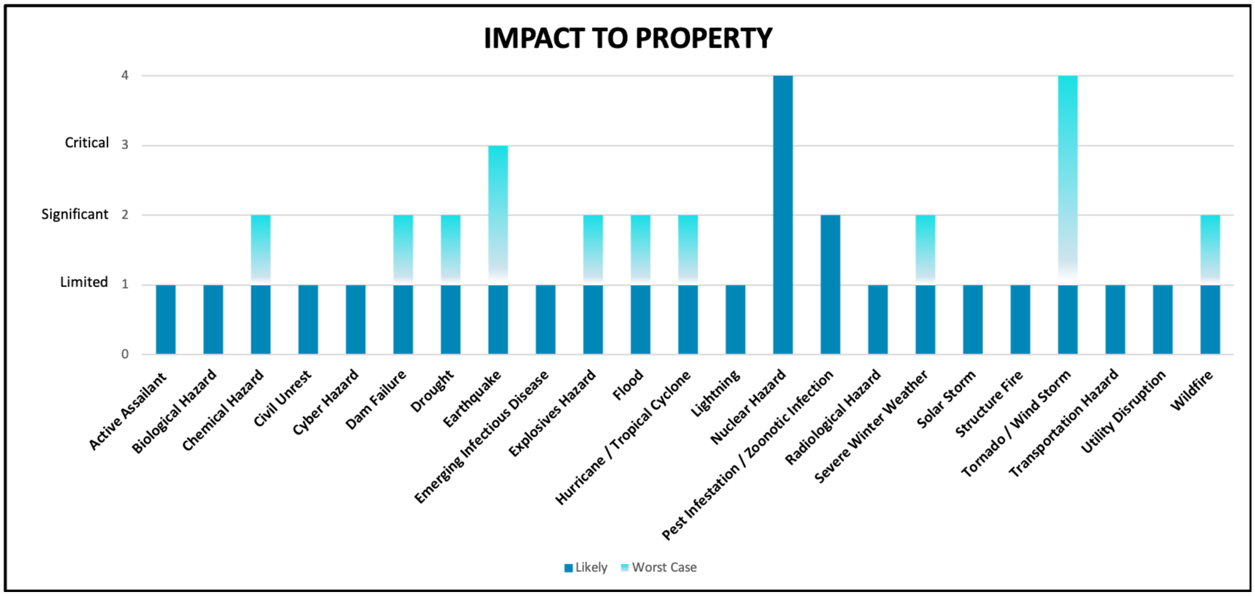
The Total Impact chart lists hazards by Total Impact Score. Total Impact is a combined measure that includes impact to property, health and safety, critical facilities, response capacity, the environment, and the economy.



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Impact to Property

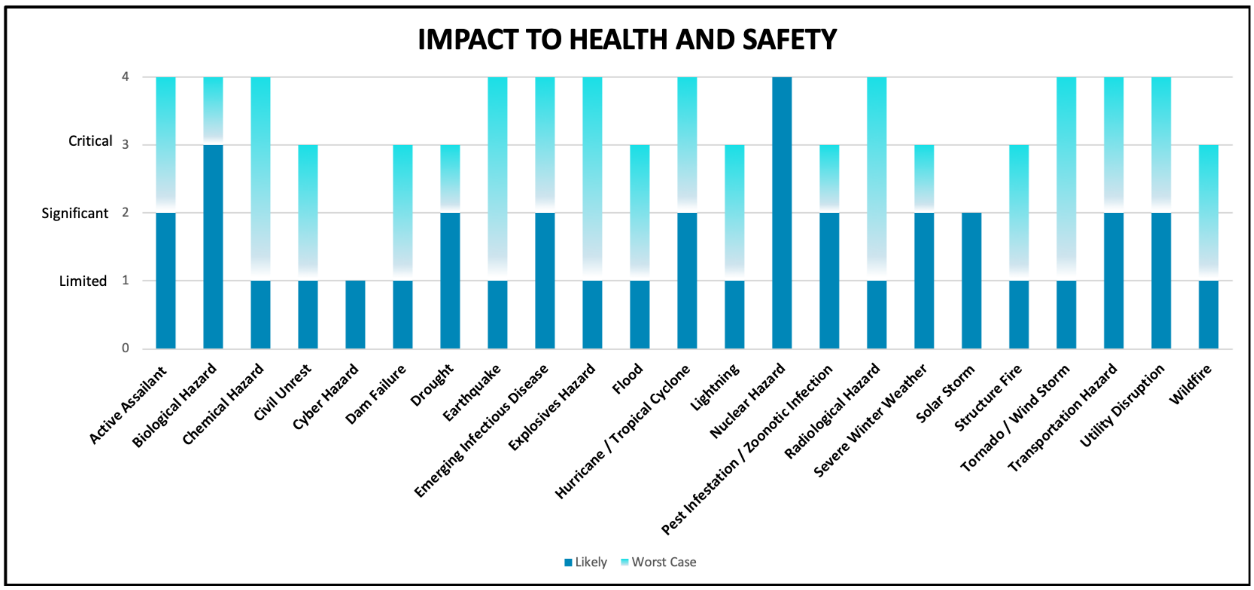
The Impact to Property chart lists hazards and their associated impact to critical and non-critical infrastructure.



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Impact to Health and Safety

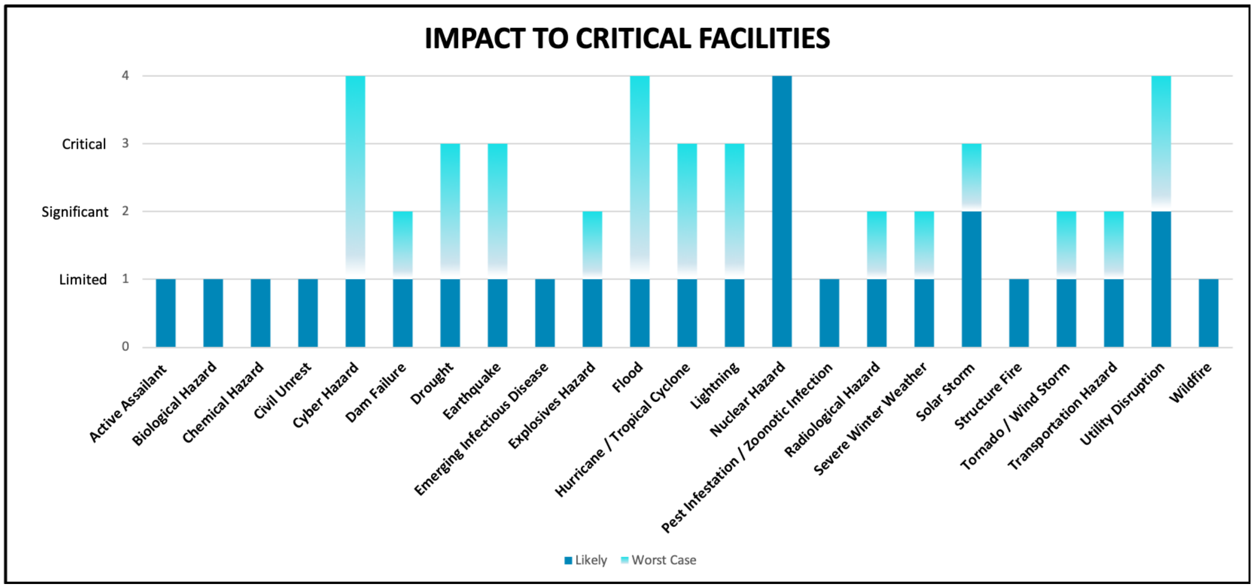
The Impact to Health and Safety chart lists hazards and their associated impact to life and health.



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Impact to Critical Facilities

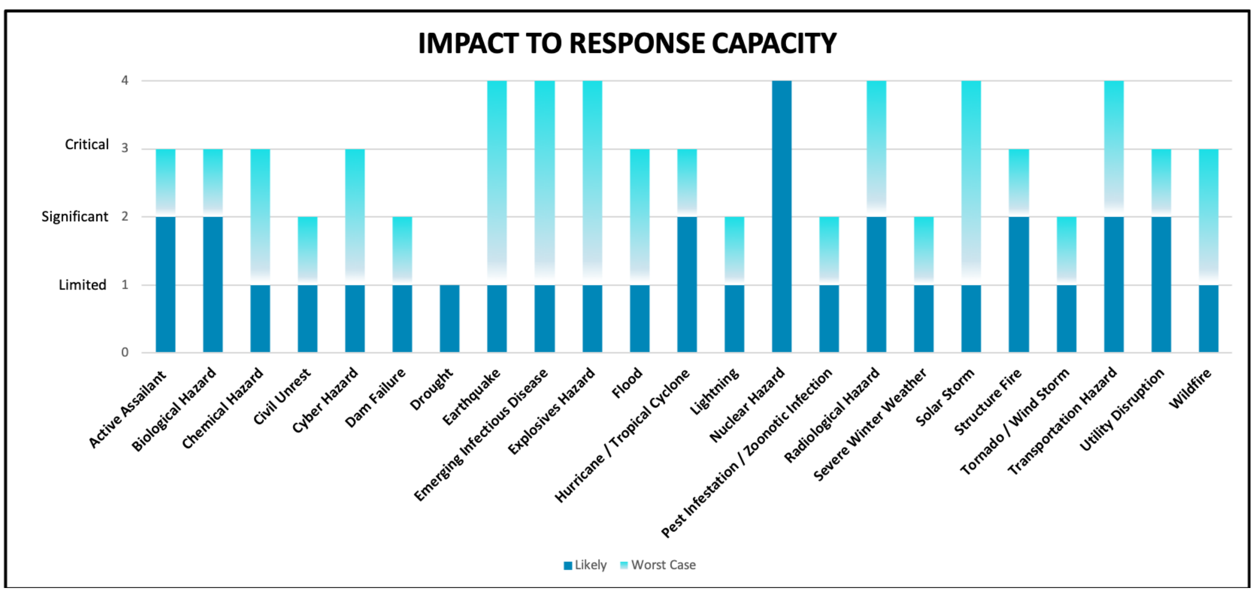
The Impact to Critical Facilities chart lists hazards and their associated impact to critical functions including utilities, information/communication systems, and transportation.



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Impact to Response Capacity

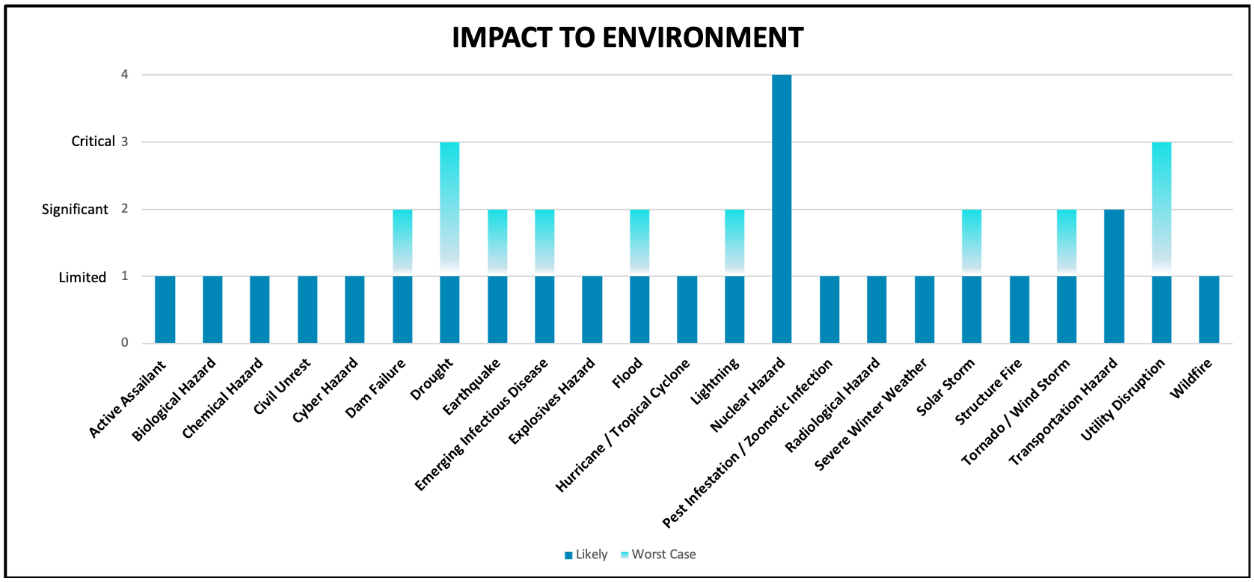
The Impact to Response Capacity chart lists hazards and their associated impact to response systems including police, fire and rescue, health, hospitals, and emergency management.



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Impact to the Environment

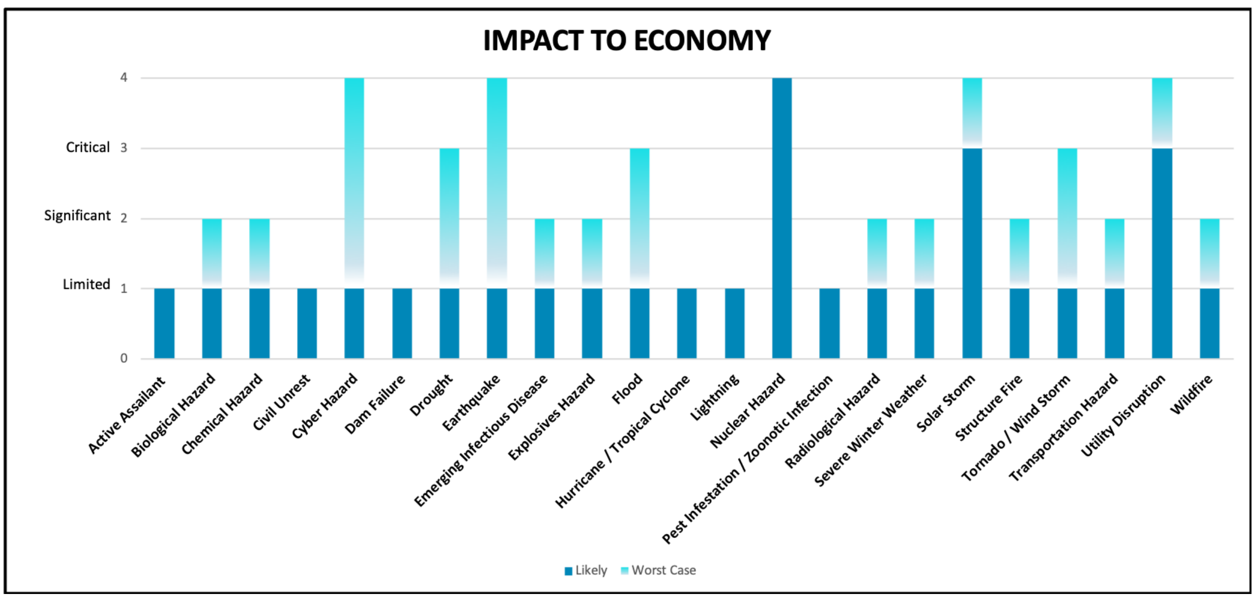
The Impact to the Environment chart lists hazards and their associated impact to the air, land, water, and wildlife.



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Impact to the Economy

The Impact to the Economy chart lists hazards and their associated impact to the gross domestic product and economic functions in the region.



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

SECTION 7
MANMADE HAZARD PROFILE

Active Assailant

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

An Active Assailant**Error! Bookmark not defined.** refers to "an individual actively engaged in killing or attempting to kill people in a confined and populated area. In most cases, active assailants use firearm(s) and have no pattern or method to their selection of victims, which creates an unpredictable and quickly evolving situation that can result in loss of life and injury. Other active assailant attack methods may also include bladed weapons, vehicles, and improvised explosive devices."[23] Active shooters are considered active assailants. In the 2015 HIRA, this hazard was referred to as "Active Shooter Hazard", however, the hazard title has been updated to "Active Assailant" to encompass more attack methods that may be used by an assailant as the landscape of the threat is continually changing.

Risk Profile

The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

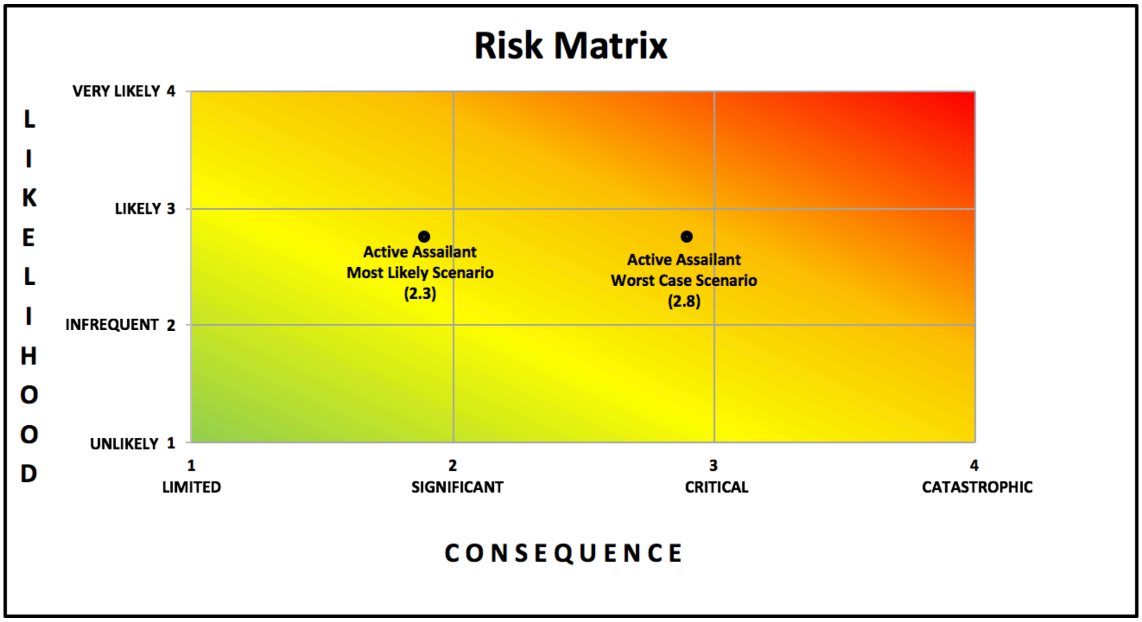
Active Assailant Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	2.75 Infrequent-Likely		50%
CONSEQUENCE	**Impact**	1.8 Limited-Significant	3 Critical	40%
	Warning Time	4 Short	4 Short	5%
	Duration	1 Short	1 Short	5%
TOTAL RISK SCORE		**2.3**	**2.8**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

[23] *Active Shooter Attacks Security Awareness for Soft Targets and Crowded Places*, Department of Homeland Security. Available at: https://www.dhs.gov/sites/default/files/publications/Active Shooter Attacks - Security Awareness for ST-CP.PDF (last accessed, June 14th, 2019).

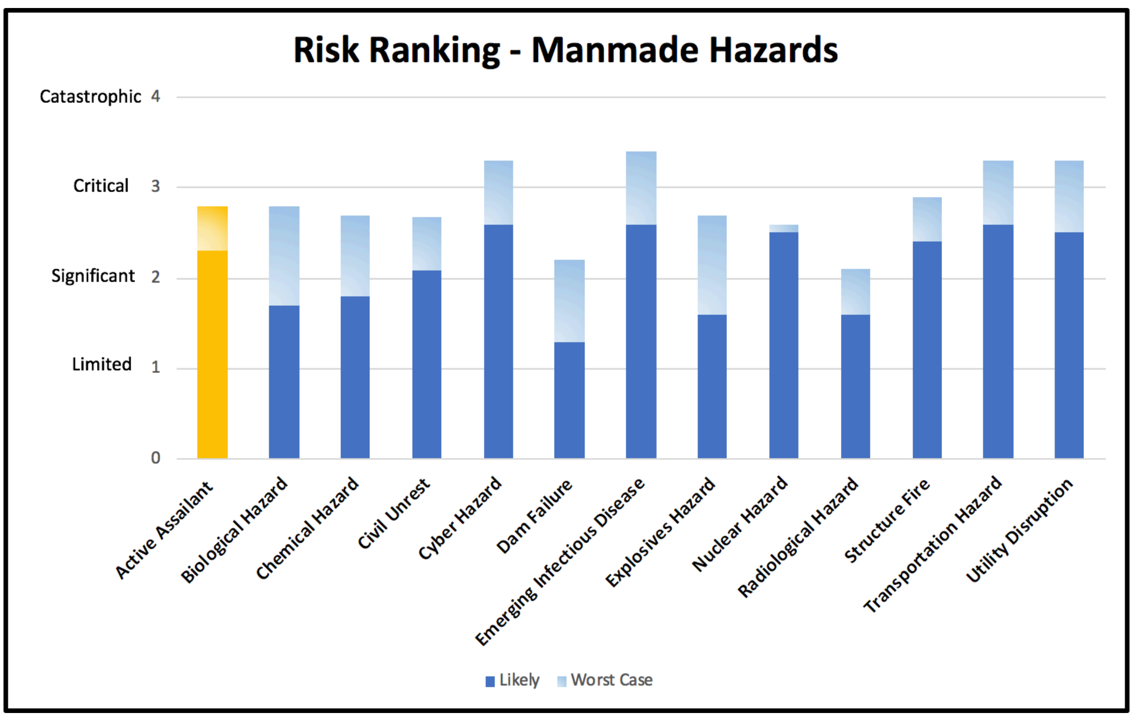
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

The range of weapons include for an Active Assailant includes: handguns, hunting rifles, assault rifles, shotguns, knives and vehicles. “Attackers preferred the use of handguns over other weapons. 24% of attackers demonstrated tactical training and awareness. 19% of attackers used body armor during their attack. 42% of attackers carried more than one weapon.”[24] Due to the preference of handguns over other weapons, the following statistics involve both active assailant attacks generally and active shooter attacks.

The New York Police Department’s (NYPD) 2016 analysis shows “that less than 25% of attacks included in the active shooter data set took place at schools, and roughly 40% occurred at commercial facilities, such as office buildings, factories and warehouses, and open commercial areas. Moreover, […] attacks at restricted commercial facilities, such as office buildings, factories, and warehouses, occurred at approximately the same frequency as attacks at open commercial facilities, such as retail stores or restaurants.”[25]

97% of active assailant incidents were carried out by a single assailant.[26] However, rare incidents involve two or more attackers, and the number of individuals involved is rarely known at the onset of the event. The NYPD’s analysis shows “that the median number of deaths in cases included in the active shooter data set is two, and the average is three.”[27] However, it is important to acknowledge the number of casualties within the more recent attacks. Specifically,

> “[i]n February 2018, 17 people including students and teachers were killed and 17 more were wounded when a gunman opened fire inside Marjory Stoneman Douglas High School in Parkland, Florida. In October 2017, 58 people were killed and 851 were injured when a gunman opened fire

[24] O’Neill, J. P., Miller, J. J., and Waters, J. R. (2016). *ACTIVE SHOOTER RECOMMENDATIONS AND ANALYSIS FOR RISK MITIGATION* [PDF]. New York City: New York City Police Department. https://www1.nyc.gov/assets/nypd/downloads/pdf/counterterrorism/active-shooter-analysis2016.pdf (last accessed, June 14, 2019).

[25] O’Neill, J. P., Miller, J. J., and Waters, J. R. (2016). *ACTIVE SHOOTER RECOMMENDATIONS AND ANALYSIS FOR RISK MITIGATION* [PDF]. New York City: New York City Police Department. https://www1.nyc.gov/assets/nypd/downloads/pdf/counterterrorism/active-shooter-analysis2016.pdf (last accessed, June 14, 2019).

[26] O’Neill, J. P., Miller, J. J., and Waters, J. R. (2016). *ACTIVE SHOOTER RECOMMENDATIONS AND ANALYSIS FOR RISK MITIGATION* [PDF]. New York City: New York City Police Department. https://www1.nyc.gov/assets/nypd/downloads/pdf/counterterrorism/active-shooter-analysis2016.pdf (last accessed, June 14, 2019).

[27] The analysis acknowledges that, “active shooter data set includes a small number of attacks with a large number of casualties; these cases inflate the average. For this reason, the median is a better measure of the typical number of casualties than the average.” Citation: O’Neill, J. P., Miller, J. J., and Waters, J. R. (2016). *ACTIVE SHOOTER RECOMMENDATIONS AND ANALYSIS FOR RISK MITIGATION* [PDF]. New York City: New York City Police Department. https://www1.nyc.gov/assets/nypd/downloads/pdf/counterterrorism/active-shooter-analysis2016.pdf (last accessed, June 14, 2019).

> from the window of a hotel room on a crowd of concert goers at the Route 91 Harvest Music Festival on the Las Vegas Strip in Nevada."[28] Additionally, "6% of attacks led to a barricade situation, and in only 4% of cases did the attacker take hostages. 17% of attackers targeted law enforcement or military personnel."[29]

The warning time for active assailant attacks range. "At least 15% of attackers indicated an imminent attack on any of their social media networks, including but not limited to Facebook, Twitter, blogs, forums, and YouTube. At least 23% of attackers were inspired by previous active shooter situations or ideologies that espoused violent shootings as a means of support for their movement."[30] An active assailant attack typically lasts less than 15 minutes. However, it can take several hours to neutralize the threat and ensure that the area is safe. Very few active assailant attacks last longer than one day.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

An Active Assailant attack can occur anywhere in Howard County. Likely targets for Active Assailant attacks in Howard County include densely populated public areas such as schools, commercial facilities, event venues, and office buildings. However, Active Assailant attacks in the United States have involved an extremely wide range of locations, weapons, and motivating factors, and it is difficult to predict specific locations or vulnerability factors at a county level.[31]

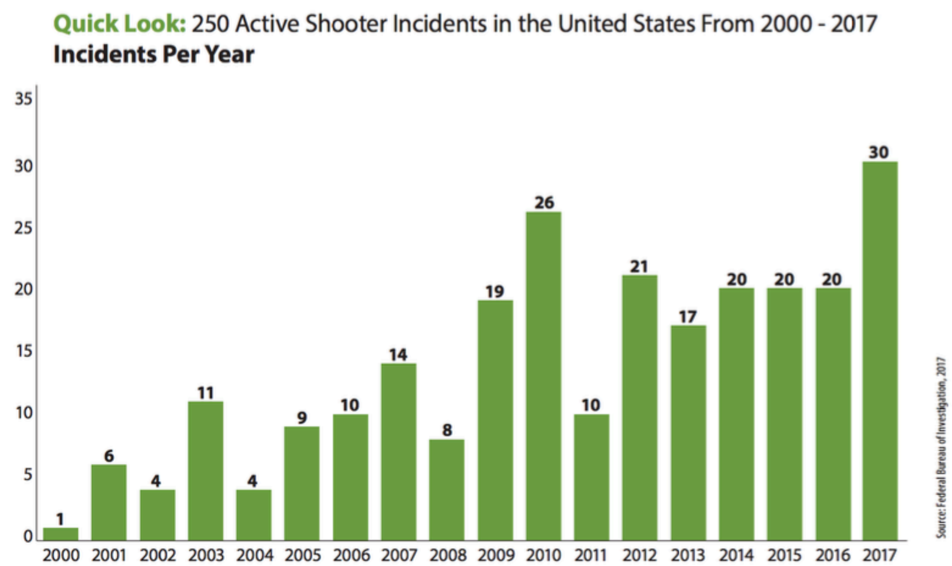
[28] *Active Shooter Attacks Security Awareness for Soft Targets and Crowded Places*, Department of Homeland Security. Available at: https://www.dhs.gov/sites/default/files/publications/19_0424_cisa_soft-targets-and-crowded-places-resource-guide.pdf last accessed, June 14th, 2019).

[29] O'Neill, J. P., Miller, J. J., and Waters, J. R. (2016). *ACTIVE SHOOTER RECOMMENDATIONS AND ANALYSIS FOR RISK MITIGATION* [PDF]. New York City: New York City Police Department. https://www1.nyc.gov/assets/nypd/downloads/pdf/counterterrorism/active-shooter-analysis2016.pdf (last accessed, June 14, 2019).

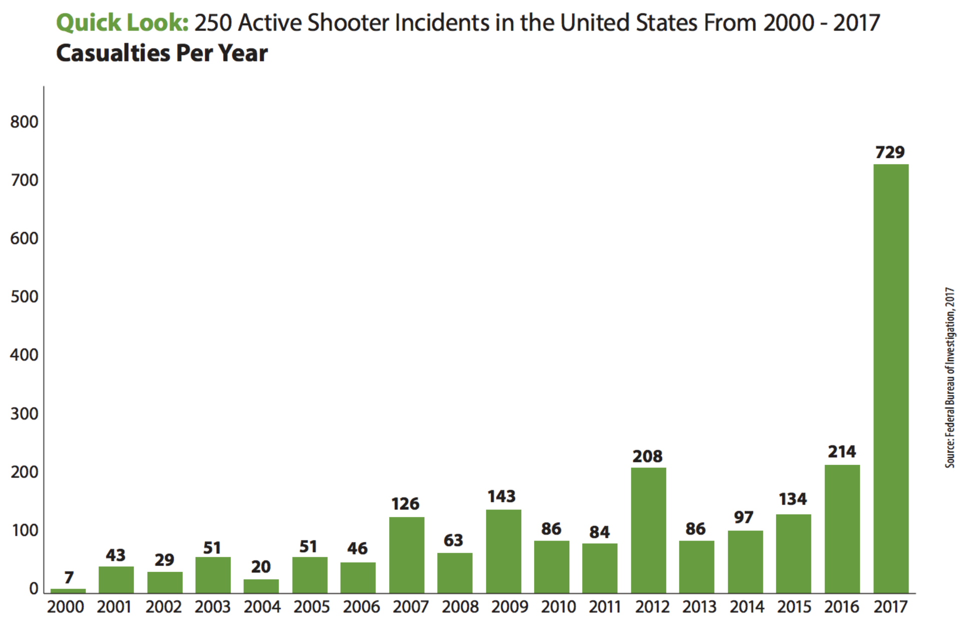
[30] O'Neill, J. P., Miller, J. J., and Waters, J. R. (2016). *ACTIVE SHOOTER RECOMMENDATIONS AND ANALYSIS FOR RISK MITIGATION* [PDF]. New York City: New York City Police Department. https://www1.nyc.gov/assets/nypd/downloads/pdf/counterterrorism/active-shooter-analysis2016.pdf (last accessed, June 14, 2019).

[31] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

The following graphs reflect active shooter data within the United States, inclusive of firearms only, not all forms of attack:



[32]



[33]

[32] "The above bar chart contains the numbers of active shooter incidents in the United States, broken down by year, from 2000 to 2017. Those yearly numbers are: 2000, one incident; 2001, six incidents; 2002, four incidents; 2003, 11 incidents; 2004, four incidents; 2005, nine incidents; 2006, 10 incidents; 2007, 14 incidents; 2008, eight incidents; 2009, 19 incidents; 2010, 26 incidents; 2011, 10 incidents; 2012, 21 incidents; 2013, 17 incidents; 2014, 20 incidents; 2015, 20 incidents; 2016, 20 incidents; and 2017, 30 incidents. The total number of active shooter incidents during the time frame was 250." Citing: FBI. (2016, June 9). Quick Look: 250 Active Shooter Incidents in the United States Between 2000-2017. Retrieved from https://www.fbi.gov/about/partnerships/office-of-partner-engagement/active-shooter-incidents-graphics.

[33] "The above bar chart contains statistics, broken down by year, of the number of casualties that resulted from active shooter incidents from 2000 to 2017. Those yearly numbers are: 2000, seven; 2001, 43; 2002, 29; 2003, 51; 2004, 20; 2005, 51; 2006, 46; 2007, 126; 2008, 63; 2009, 143; 2010, 86; 2011, 84; 2012, 208; 2013, 86; 2014, 97; 2015, 134; 2016, 214; and 2017, 729. The total

According to a report published by the U.S. Department of Justice Federal Bureau of Investigation, there have been seven active assailant incidents in Maryland since 2012[34]. These incidents are listed in the report as:

- "On August 27th, 2012, at 10:45 a.m., Robert Wayne Gladden Jr., 15, armed with a shotgun, shot a classmate in the cafeteria of Perry Hall High School in Baltimore, Maryland. The shooter had an altercation with another student before the shooting began. He left the cafeteria and returned with a gun. No one was killed; one person was wounded. The shooter was restrained by a guidance counselor before being taken into custody by the school's resource officer."[35]

- "On January 25th, 2014, at 11:15 a.m., Darion Marcus Aguilar, 19, armed with a shotgun and explosive devices, began shooting in The Mall in Columbia in Columbia, Maryland, first in a retail store, then in the open mall. Two store employees were killed; five mall patrons were wounded. One person was shot in the ankle and 4 others suffered other medical emergencies. The shooter committed suicide before law enforcement arrived."[36]

- "On March 13th, 2016, at 4:30 p.m., Michael Ford, 22, armed with a handgun, allegedly began shooting at the Prince George's County Police Department District 3 station in Landover, Maryland. One plainclothes law enforcement officer was killed by friendly fire; no one was wounded. The shooter was wounded in an exchange of gunfire with law enforcement officers before being apprehended."[37]

- "On October 18th, 2017, at 8:58 a.m., Radee Labeeb Prince, 37, armed with a handgun, allegedly began shooting fellow employees at Advanced Granite Solutions in Edgewood, Maryland. After killing three people and wounding two, the shooter fled the scene and traveled 52 miles to the 28th Street Auto Sales and Service lot in Wilmington, Delaware, where he shot and wounded another person. A total of three people were killed; three were wounded. The shooter was apprehended by law enforcement later that night in Newark, Delaware."[38]

- "On December 15th, 2017, at 2:55 p.m., Mausean Vittorio Quran Carter, 30, armed with a rifle and handgun, allegedly began shooting indiscriminately at pedestrians from his vehicle after fleeing from a traffic stop by a law enforcement officer in Baltimore, Maryland, in connection to a triple

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number of casualties for this time frame was 2,217." Citing: FBI. (2016, June 9). Quick Look: 250 Active Shooter Incidents in the United States Between 2000-2017. Retrieved from https://www.fbi.gov/about/partnerships/office-of-partner-engagement/active-shooter-incidents-graphics.

[34] U.S. Department of Justice Federal Bureau of Investigation. Active Shooter Incidents in the United States from 2000-2018. (last accessed, September 17, 2019).

[35] U.S. Department of Justice Federal Bureau of Investigation. Active Shooter Incidents in the United States from 2000-2018. (last accessed, September 17, 2019).

[36] U.S. Department of Justice Federal Bureau of Investigation. Active Shooter Incidents in the United States from 2000-2018. (last accessed, September 17, 2019).

[37] U.S. Department of Justice Federal Bureau of Investigation. Active Shooter Incidents in the United States from 2000-2018. (last accessed, September 17, 2019).

[38] U.S. Department of Justice Federal Bureau of Investigation. Active Shooter Incidents in the United States from 2000-2018. (last accessed, September 17, 2019).

shooting the previous week. After a 30-minute pursuit, the shooter came to a stop. His girlfriend, who had been communicating with the shooter by phone during the chase, ran up to the car and pulled him out of his seat, bringing the chase to an end. No one was killed; three were wounded, including one law enforcement officer. The shooter was apprehended by law enforcement."[39]

- "On June 29th, 2018, at 2:34 p.m., Jarrod Warren Ramos, 38, armed with a shotgun, began shooting in the Capital Gazette news offices in Annapolis, Maryland. Although the shooter had smoke grenades in his backpack, he did not deploy them. Five people were killed; two were wounded. The shooter was apprehended by law enforcement at the scene."[40]

- "On September 20th, 2018, at 9:06 a.m., Snochia Moseley (female), 26, armed with a handgun, began shooting at coworkers during her shift at the Rite Aid Perryman Distribution Center's Liberty support center in Aberdeen, Maryland. The shooter was a temporary employee at the facility. Three were killed; three were wounded. The shooter committed suicide at the scene before law enforcement arrived".[41]

[39] U.S. Department of Justice Federal Bureau of Investigation. Active Shooter Incidents in the United States from 2000-2018. (last accessed, September 17, 2019).
[40] U.S. Department of Justice Federal Bureau of Investigation. Active Shooter Incidents in the United States from 2000-2018. (last accessed, September 17, 2019).
[41] U.S. Department of Justice Federal Bureau of Investigation. Active Shooter Incidents in the United States from 2000-2018. (last accessed, September 17, 2019).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

There has been one Active Assailant event in Howard County during the reviewed time period (1964-2019).

Notable Incidents in Howard County

2014 Columbia Mall Shooting - A single assailant brought a concealed shotgun and several crude explosives into The Mall in Columbia on January 25th, 2014. The shooter opened fire in a second-story retail store, killing two employees, striking a third person in the ankle, and ultimately taking his own life. The assailant did not know any of the victims prior to the attack.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of an Active Assailant in Howard County	
Historical Average (time period)	1 event every 50 years (1964-2019)
Historical Annual Probability	2% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	1-30% chance of annual occurrence.
Future Likelihood Score	2.75 (Infrequent- Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: The future likelihood of an Active Assailant attack in Howard County is expected to be higher than indicated by the historical occurrence rate alone. Likelihood estimates for a future attack have a wide range of variability, but current estimates predict a 1-30% chance of annual occurrence, or one event every 3-99 years. The increased amount of Active Assailant attacks[42] and increased media attention at the national level both contribute to the increased likelihood of Active Assailant attacks in the future. Other considerations that were measured to increase the future likelihood were the proximity of Howard County to the metropolitan areas (Washington, D.C., Baltimore, Maryland), the amount of government buildings within the County, the amount of large open and population-dense areas, and an overall false

[42] *Active Shooter Events from 2000-2012,* Federal Bureau of Investigation (2014). Available at http://leb.fbi.gov/2014/january/active-shooter-events-from-2000-to-2012 (last accessed October 17, 2019).

sense of security within those population-dense areas. The current political climate in addition to Howard County's proximity to large political/cultural events also impact the likelihood of the hazard.

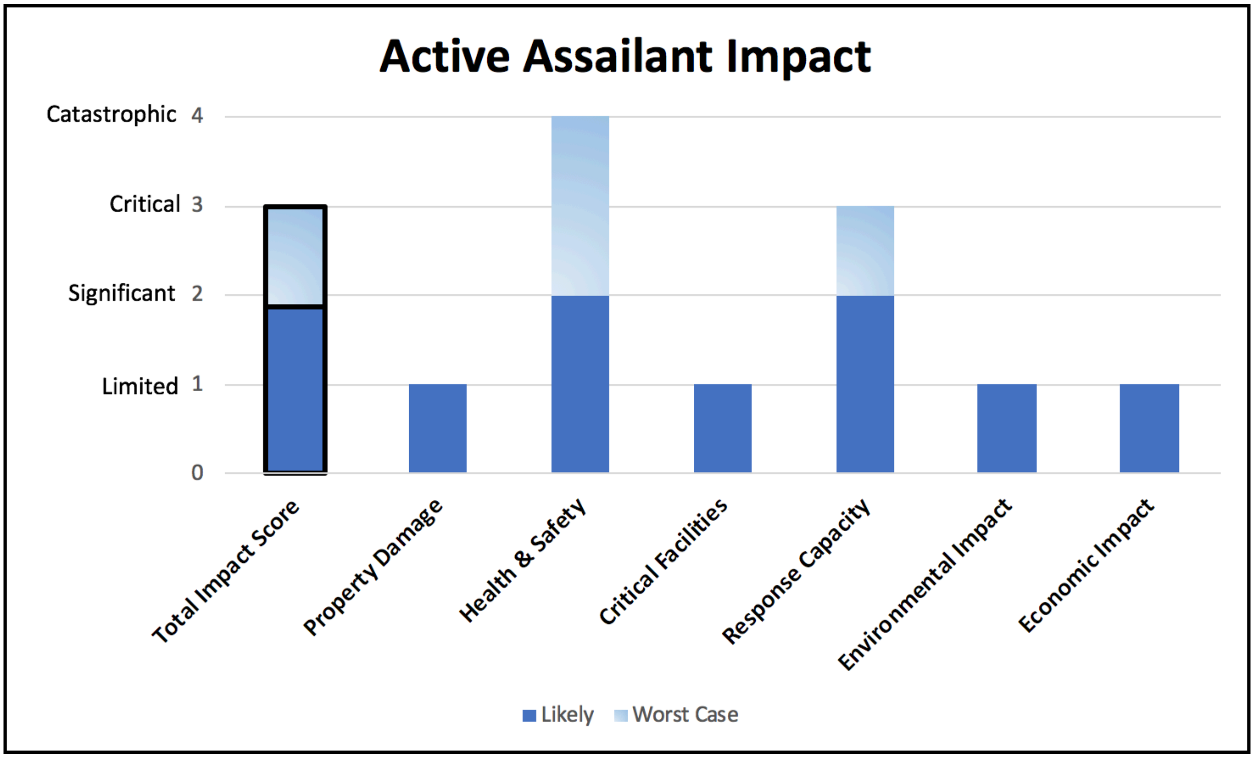
It is important to note that there is a common misconception that increased prevalence of mental illness is linked to Active Assailant attacks. Studies show that those with mental illness diagnoses are more likely to be a victim of an act of violence, rather than the perpetrator. According to a study published by the American Psychiatric Association, "mass shootings by people with serious mental illness represent less than 1% of all yearly gun-related homicides. In contrast, deaths by suicide using firearms account for the majority of yearly gun-related deaths. The overall contribution of people with serious mental illness to violent crimes is only about 3%. When these crimes are examined in detail, an even smaller percentage of them are found to involve firearms."[43]

[43] James L. Knoll IV, M.D., and George D. Annas, M.D., M.P.H. (2016). Mass Shootings and Mental Illness. Retrieved from https://psychiatryonline.org/doi/pdf/10.5555/appi.books.9781615371099 (last accessed October 18, 2019). *See also*: Metzl, J. M., and MacLeish, K. T. (2015). Mental illness, mass shootings, and the politics of American firearms. *American journal of public health*, *105*(2), 240–249. doi:10.2105/AJPH.2014.302242

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Active Assailant Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time prior to an attack.	*Short.* No warning time prior to an attack.
DURATION	*Short.* Seven to eight minutes for initial attack, one to two hours to establish that the hazard has been neutralized and the area is safe.	*Short.* 15 minutes for initial attack, one to two hours to establish that the hazard has been neutralized and the area is safe.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Active Assailant Consequence Analysis **Likely**		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Bullet holes may cause superficial damage. Anything beyond superficial damage to buildings and structures is unlikely.
HEALTH AND SAFETY	*Significant*	▪ Zero to three deaths likely. Most deaths would likely be due to penetrating trauma and blood loss from bullet wounds. ▪ Five to seven individuals are struck with firearm rounds or debris. ▪ Most injuries would likely be due to penetrating trauma from bullet wounds.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Traffic delays for less than one day. Public mobility will be impacted in a localized area.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Mutual aid needed. No great impact to response capability. Road manpower will be slightly reduced. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state or Federal assistance. Mutual aid resources will be necessary to cover calls during event until units can be cleared. ▪ *Health* – Local resources adequate. Health Department (HD) operations will not be affected. ▪ *Hospitals* – Local resources adequate. No impact on the hospital system. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited to no environmental impact. Less than a day of clean-up. Impact to a localized area.
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. ▪ Zero jobs lost. ▪ Temporary business disruption in the area of the attack. Damage to image possible.
TOTAL IMPACT[1]	***Limited - Significant***	▪ **Total Impact Score: 1.875 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[1] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

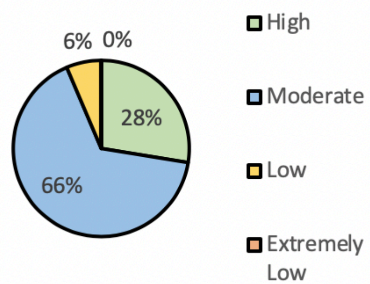
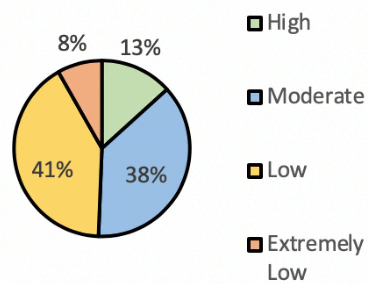
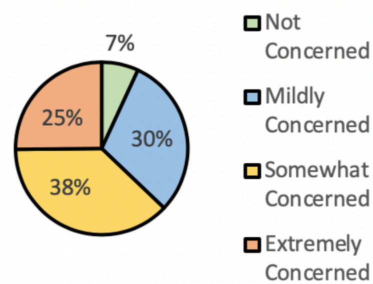
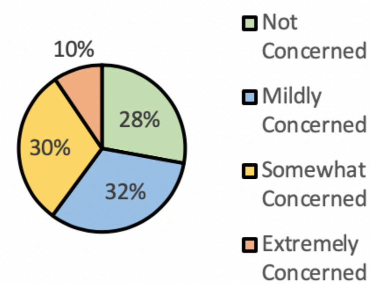
Active Assailant Consequence Analysis **Worst-Case**		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Bullet holes may cause superficial damage. Anything beyond superficial damage to buildings and structures is unlikely.
HEALTH AND SAFETY	*Catastrophic*	▪ 10-20 deaths likely. Most deaths would likely be due to penetrating trauma and blood loss from bullet wounds. ▪ 30-40 injuries likely. Most injuries would likely be due to penetrating trauma from bullet wounds.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Traffic delays for less than one day. Public mobility will be impacted in a localized area.
RESPONSE CAPACITY	*Critical*	▪ *Police* – Mutual aid needed. No great impact to response capability. Road manpower will be slightly reduced. Assistance will be needed to support both tactical and patrol efforts. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state or Federal assistance. Significant impact on fire/EMS capability. Significant mutual aid would be required to maintain regular calls for service and incident support. ▪ *Health* – Moderate need for state or Federal assistance. Essential HD functions likely will not be affected. Emergency and Response, Public Information Office (PIO) and Community Health could be needed to support local response. ▪ *Hospitals* – Mutual aid needed. Patient surge could cause delays in the Emergency Department. The hospital would treat minor injuries and stabilize major injuries, but trauma patients would be diverted to trauma centers. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited to no environmental impact. Less than a day of clean-up. Impact to a localized area.
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. Other costs include cleanup and healthcare for those affected. ▪ Zero jobs lost. ▪ Temporary business disruption in the area of the attack. Damage to image possible.
TOTAL IMPACT[2]	***Critical***	▪ **Total Impact Score: 3 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[2] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Active Assailant Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
 *Average: 3.21* *Moderate - High*	 *Average: 2.56* *Low - Moderate*	 *Average: 2.81* *Mildly Concerned - Somewhat Concerned*	 *Average: 2.22* *Mildly Concerned - Somewhat Concerned*

Biological Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

In the updated 2019 Howard County HIRA document, Biological Hazards have been expanded to include all Biological Hazards, both intentional and unintentional. Emerging/Re-emerging Infectious Diseases are discussed as a separate hazard.

A Biological Hazard can be intentional or unintentional. An intentional Biological Hazard (Attack) is, "the intentional release of a pathogen (disease causing agent) or biotoxin (poisonous substance produced by a living organism) against humans, plants, or animals. An attack against people could be used to cause illness, death, fear, societal disruption, and economic damage. An attack on agricultural plants and animals would primarily cause economic damage, loss of confidence in the food supply, and possible loss of life."[46] The DHS further describes the hazard as distinguishable between two types of biological agents: "(1) Transmissible agents that spread from person to person (e.g., smallpox, Ebola) or animal to animal (e.g., foot and mouth disease). (2) Agents that may cause adverse effects in exposed individuals but that do not make those individuals contagious to others (e.g., anthrax, botulinum toxin)."[47] Biological agents can be introduced and spread through a population by air, direct contact, water, or food.

An Unintentional Biological Hazard can result from the natural spread of infectious disease or from the accidental release of biological agents from health care facilities, research institutions, and industrial operations. The accidental release of harmful biological agents may occur if these agents are not stored correctly, if safety controls malfunction, or if safety procedures are not followed. The spread of infectious diseases most commonly occurs naturally as potentially harmful biological agents are passed from one person to another, acquired through contaminated food or water, or transmitted via animal bite.

[46] Biological Attack Fact Sheet. (2019, March 13). Retrieved from https://www.dhs.gov/publication/biological-attack-fact-sheet (last accessed October 10, 2019).
[47] Biological Attack Fact Sheet. (2019, March 13). Retrieved from https://www.dhs.gov/publication/biological-attack-fact-sheet (last accessed October 10, 2019).

Although biological agents are not easy to grow and maintain, once introduced to a population they can be challenging to detect.

Risk Profile

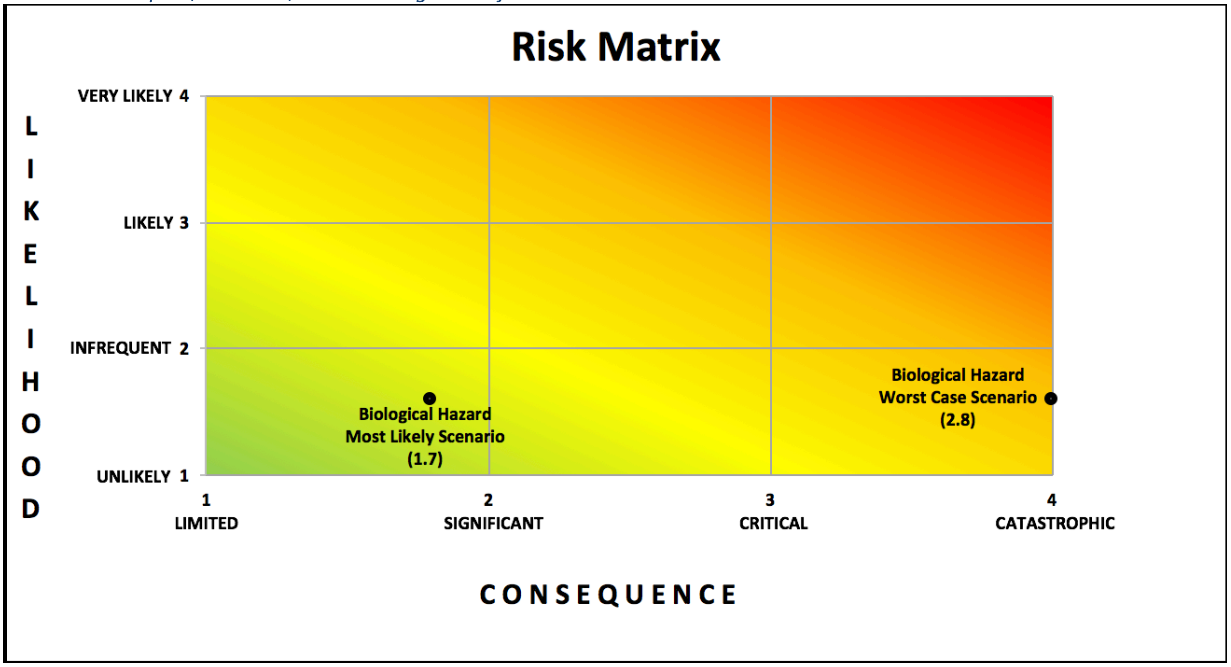
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Biological Hazard Risk Profile					
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	1.6 Unlikely-Infrequent		50%
CONSEQUENCE	**Impact**	1.3 Limited-Significant	4 Catastrophic	40%
	Warning Time	4 Short	4 Short	5%
	Duration	4 Very Long	4 Very Long	5%
TOTAL RISK SCORE		**1.7**	**2.8**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

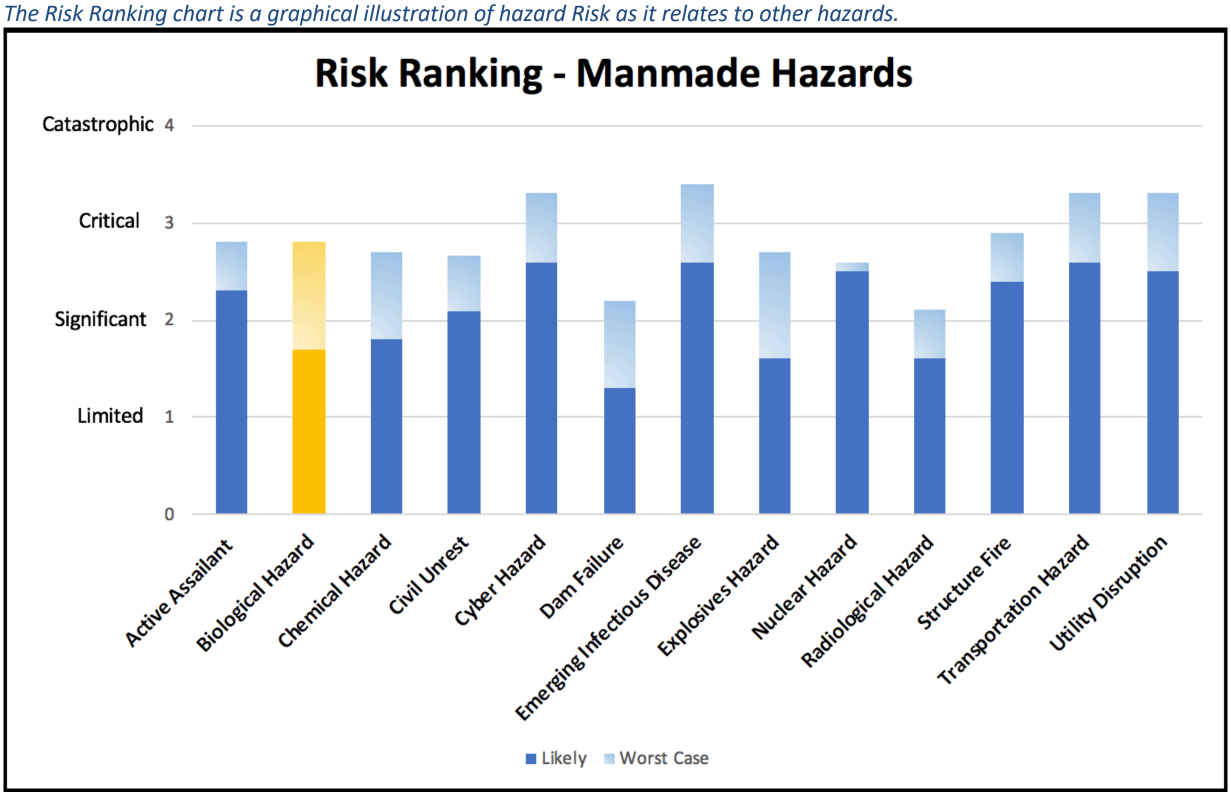
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

The Centers for Disease Control and Prevention (CDC) separates bioterrorism agents into three categories based on how easily they can be spread and the severity of illness or death they cause. Category A agents pose the highest risk to the public and national security, Category B agents are the second highest priority, and Category C agents represent emerging threats.[48]

Category A agents

- Can be easily spread or transmitted from person to person
- Result in high death rates and have the potential for major public health impact
- Might cause public panic and social disruption
- Require special action for public health preparedness[49]

Category B agents

- Are moderately easy to spread
- Result in moderate illness rates and low death rates
- Require specific enhancements of laboratory capacity and enhanced disease monitoring[50]

Category C agents

- Could be engineered for mass spread in the future
- Are easily available
- Are easily produced and spread
- Have potential for high morbidity and mortality rates and major health impact in the future[51]

A biological disease agent can be delivered in a variety of ways. Some attack methods are overt, such as the delivery of an agent through the mail. Other methods involve discreet introduction into air, food, or water, and those infected may not even realize they have been the subjects of an attack.[52]

[48] CDC. (2018, April 4). CDC | Bioterrorism Agents/Diseases (by category) | Emergency Preparedness and Response. Retrieved from https://emergency.cdc.gov/agent/agentlist-category.asp (last accessed September 19, 2019).
[49] CDC. (2018, April 4). CDC | Bioterrorism Agents/Diseases (by category) | Emergency Preparedness and Response. Retrieved from https://emergency.cdc.gov/agent/agentlist-category.asp (last accessed September 19, 2019).
[50] CDC. (2018, April 4). CDC | Bioterrorism Agents/Diseases (by category) | Emergency Preparedness and Response. Retrieved from https://emergency.cdc.gov/agent/agentlist-category.asp (last accessed September 19, 2019).
[51] CDC. (2018, April 4). CDC | Bioterrorism Agents/Diseases (by category) | Emergency Preparedness and Response. Retrieved from https://emergency.cdc.gov/agent/agentlist-category.asp (last accessed September 19, 2019).
[52] *Biological Attack: What It Is*, U.S. Dept. of Homeland Security. Available at http://www.dhs.gov/biological-attack-what-it (last accessed October 10, 2019).

It is rare to have any advanced warning of a Biological Attack. In the event of a discrete release of an easily spread biological agent, the attack may be unrecognized for days or even weeks following the initial release.

The number of people affected by a Biological Attack is largely dependent on the location of the attack and the agent involved. Biological Attacks can directly affect a wide range of people: as few as one person or as many as millions. Factors that affect the number of people who come into contact with the agent include the ease of transmission, the area affected, and the population density at the point of attack. Some biological agents can be dealt with using existing laboratory and monitoring capacity. However, others may require significant enhancement of laboratory and monitoring capabilities.

Not all biological agents are contagious, and there is quite a bit of variability when it comes to disease spread. For example, some biological agents may cause adverse effects in individuals, but may not result in those individuals becoming contagious. Other biological agents are very difficult to spread and require contact with bodily fluids or other special circumstances to transmit disease. The most contagious biological agents can be quickly and easily spread from person to person through means that require little to no direct contact with an infected individual.

There is significant variability in the severity of illness caused by biological agents. Many agents cause pain or discomfort with few lasting effects. However, some agents can cause permanent damage or death. Deaths from disease can vary greatly depending on the biological agent in question, with case fatality rates ranging from 0% to nearly 100%.

The most common Unintentional Biological Hazard events are caused by the natural spread of infectious diseases. These disease outbreaks occur naturally as potentially harmful biological agents are passed from one person to another, acquired through contaminated food or water, or transmitted via animal bite. However, Unintentional Biological Hazards may also occur if disease agents are accidentally released from health care facilities, research institutions, and industrial operations. Individuals may be exposed to harmful biological agents if the agents are not stored correctly, if safety controls malfunction, or if safety procedures are not followed. It is rare to have any advanced warning of an Unintentional Biological Hazard. Adding complexity to the issue, the existence of an Unintentional Biological Hazard may not be recognized for days or even weeks after the start of the disease spread. Depending on the characteristics of the biological agent and the spread of disease, Unintentional Biological Hazards can directly affect as few as one person or as many as millions.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

There have been multiple Biological Attacks that have occurred within the United States. Since 2000, there have been two notable events relating to Biological Attacks. In 2001, "Anthrax-laced of infectious anthrax were delivered to news media offices and the US Congress"[53] Additionally, on February 3, 2004, "three U.S. Senate office buildings were closed after the toxin ricin was found in a mailroom that serves Senate Majority Leader Bill Frist's office."[54]

A Biological Attack may occur anywhere in Howard County. Likely targets for Biological Attacks in Howard County include densely populated public areas such as schools, commercial facilities, event venues, and office buildings.

The location of Howard County may increase local vulnerability to Biological Attacks and other terrorism-related attacks. Howard County is in close proximity to valuable terrorist targets including Washington, D.C., the City of Baltimore, the Port of Baltimore, and the Baltimore/Washington International Thurgood Marshall (BWI) Airport. Due to its proximity to the National Capital Region (NCR), many Federal agencies, defense contractors, and high-profile targets maintain facilities within Howard County.[55]

An Unintentional Biological Hazard can occur anywhere in Howard County. Densely populated areas are especially vulnerable to communicable disease outbreaks due to the increased speed and likelihood of disease transmission. Vulnerability to communicable diseases also increases with population mobility and increased exposure to individuals from diverse geographic regions. According to the D.C. Policy Center, "25% of workers in Anne Arundel and Howard Counties work in the D.C. metro area."[56] Additionally, the close proximity to major interstate highways, an international airport, and an international shipping port all increase Howard County's vulnerability to the introduction and spread of communicable diseases.[57]

III. LIKELIHOOD ANALYSIS

[53] Williams M, Sizemore DC. Biologic, Chemical, and Radiation Terrorism Review. [Updated 2019 Mar 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK493217/ (last accessed October 10, 2019).
[54] Hooker, E. (n.d.). Biological Warfare Facts and History of Biological Agents. Retrieved from https://www.emedicinehealth.com/biological_warfare/article_em.htm#facts_on_bioterrorism_and_biowarfare_today (last accessed October 10, 2019).
[55] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).
[56] How many people commute between Baltimore and D.C.? Retrieved from https://www.dcpolicycenter.org/publications/how-many-people-commute-between-baltimore-and-d-c/ (last accessed September 19, 2019).
[57] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

It is important to note that in the 2015 HIRA, Biological Hazards were reviewed separately as "Biological Attacks" and "Disease Epidemic/Unintentional Biological Hazards". In the updated 2019 HIRA, Biological Attacks Hazards has been expanded to include all Biological Hazards, both intentional and unintentional. Emerging/Re-emerging Infectious Diseases are discussed as a separate hazard. Due to this expansion, a higher number of the hazard occurrence is being reported as a result of more events falling within the definition of the hazard. The review period for all Biological Hazard events began the lower levels that support research and education. There have been zero confirmed Biological Attacks between 2014 and 2019. From 2014 to 2018[58], there were 88 reports of Unintentional Biological Hazards, 16 of these investigations were considered hazard events.

Notable Incidents in Howard County

Although there have been no notable Biological Attack hazard events in Howard County, the fear of Biological Attack persists. Suspicious powders and substances are frequently reported as Biological Hazards.

In 2014, the Howard County Department of Fire and Rescue Services (DFRS) responded to 21 Suspicious Package/Unknown Substance investigation incidents. Most of these incidents turned out to be harmless material or unattended packages. Three of these investigations were considered hazard events. The incidents included individuals that were evaluated and or treated for "potential" exposure to a harmful substance.[59]

In 2015, DFRS responded to 24 Suspicious Package/Unknown Substance investigation incidents. Most of these incidents turn out to be harmless material or unattended packages. Five of these investigations were considered hazard events. The incidents included individuals that were evaluated and or treated for "potential" exposure to a harmful substance.[60]

In 2016, DFRS responded to 14 Suspicious Package/Unknown Substance investigation incidents. Most of these incidents turned out to be harmless material or unattended packages. Three of these investigations were considered hazard events. The incidents included individuals that were evaluated and or treated for potential exposure to a harmful substance.[61]

[58] While the review period continued until 2019, the data we received from Subject Matter Experts did not include 2019 data.
[59] Howard County Department of Fire and Rescue Services, 2019.
[60] Howard County Department of Fire and Rescue Services, 2019.
[61] Howard County Department of Fire and Rescue Services, 2019.

In 2017, DFRS responded to 12 Suspicious Package/Unknown Substance investigation incidents. Most of these incidents turned out to be harmless material or unattended packages. Three of these investigations were considered hazard events. The incidents included individuals that were evaluated and or treated for "potential" exposure to a harmful substance.[62]

In 2018, DFRS responded to 17 Suspicious Package/Unknown Substance investigation incidents. Most of these incidents turned out to be harmless material or unattended packages. Two of these investigations were considered hazard events. The incidents included individuals that were evaluated and or treated for "potential" exposure to a harmful substance.[63]

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Biological Hazard in Howard County	
Historical Average (time period)	16 events (2014-2019)
Historical Annual Probability	30% + chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	1-10% chance of annual occurrence
Future Likelihood Score	1.6 (Unlikely-Infrequent)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: Although the future likelihood remains low, estimates predict a 1-10% chance of annual occurrence, or one event every 10-99 years. A future annual probability of 1-10% classifies the likelihood of a Biological Hazard as infrequent. Successful Biological Attacks, the increased threat of terrorism, and Howard County's proximity to high-value terrorist targets contribute to the likelihood of a Biological Attack in the future. Other considerations that would impact the future likelihood of this hazard include Howard County having a highly educated population that can learn how to make a biological agent; proximity of medical institutions; the high amount of people traveling internationally and within the County which increases exposure to a biological agent; proximity of lab corporations; and that there is not a robust mail-checking system.

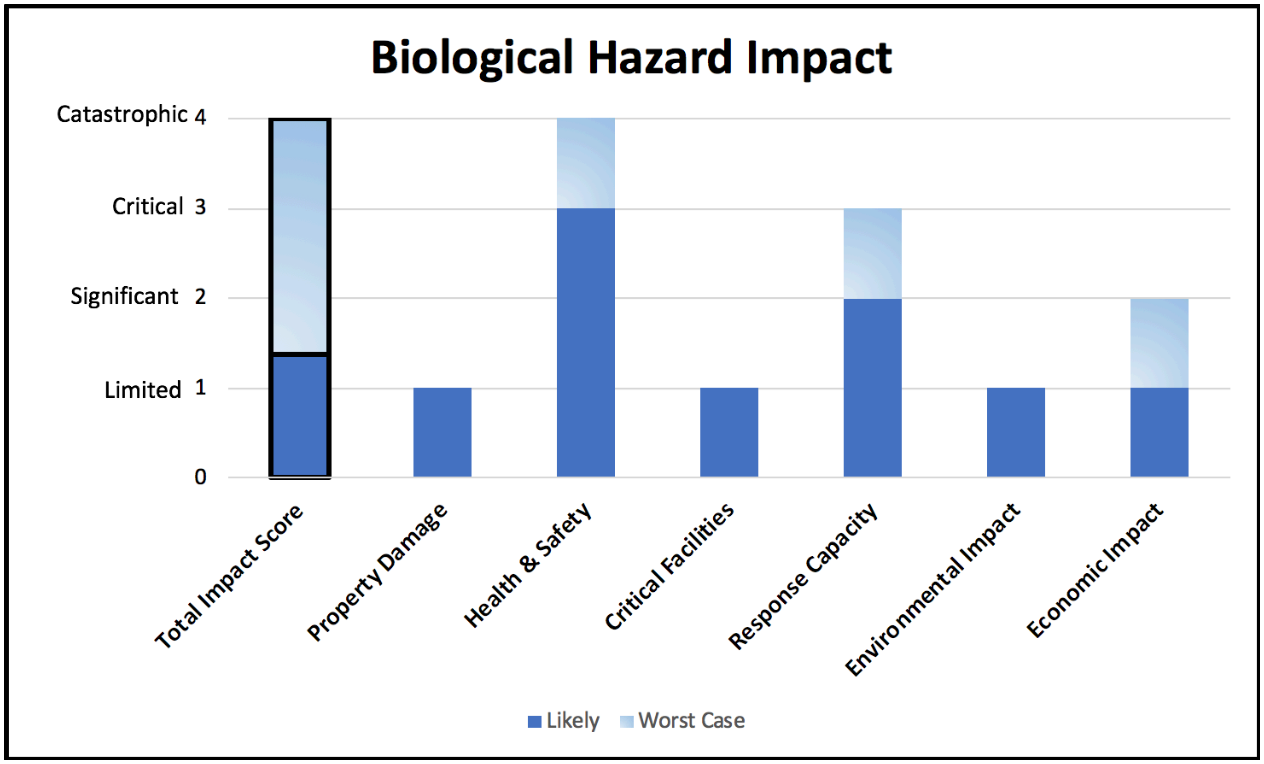
IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the

[62] Howard County Department of Fire and Rescue Services, 2019.
[63] Howard County Department of Fire and Rescue Services, 2019.

environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Biological Hazard Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time.	*Short.* No warning time.
DURATION	*Very Long.* 15-20 minutes of exposure. Ten days for immediate medical treatment followed by three months of surveillance.	*Very Long.* 30 minutes – several hours for the initial attack. There are no new exposures after the initial attack, and it takes ten days to treat all people exposed to the disease followed by three months of surveillance. Residual health effects continue for up to one month.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Biological Hazard Consequence Analysis **Likely**		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely.
HEALTH AND SAFETY	*Critical*	▪ One to three deaths may occur if people refuse to receive any medical treatment. ▪ Five injuries likely. Many who are exposed to the agent experience vomiting, nausea, shortness of breath, or rash for one week. Symptoms are more severe for those exposed to higher doses, even with appropriate medical treatment, several may have permanent health consequences.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Shutdown unlikely. Impacts to transportation will be minor and short-term.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Mutual aid needed. Terrorism response automatically triggers federal law enforcement involvement. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Local Resources Adequate. Little to no impact on response capability and continuity of operations. ▪ *Health* – Federal and state assistance needed. Biological release associated with terrorism automatically triggers State and Federal investigations. Communicable Disease, Community Health, and Emergency Preparedness and Response will be impacted but could likely manage local response. Outside resources are needed; however, these resources are within the existing system. Point of Dispensing (PODs) will be opened to distribute medications to treat those who are exposed to the agent. ▪ *Hospitals* – Local resources adequate. Hospital system would successfully manage the patient surge. There is mass hysteria following the attack especially those fearing they may have been exposed. False cases may overwhelm the hospital causing alternate treatment sites to be opened (PODs). ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited to no environmental impact. Less than a day of clean-up. Impact to a localized area.
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. Other costs include cleanup and healthcare for those affected. ▪ Zero jobs lost. ▪ Limited businesses closure may occur depending on the location of the attack.
TOTAL IMPACT[64]	***Limited-Significant***	▪ **Total Impact Score: 1.375 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[64] The total impact score was created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

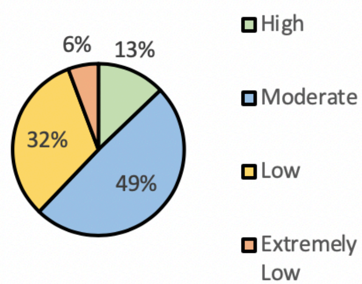
Biological Hazard Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely.
HEALTH AND SAFETY	*Catastrophic*	▪ 5,000-10,000 deaths. ▪ 100,000 injuries likely. The nature of injury and death will depend on the biological agent, but may result in any number of symptoms for approximately two to four weeks. All exposed will require hospitalization.
CRITICAL FACILITIES	*Limited*	▪ <u>Utilities</u> – Shut unlikely. Water treatment facility shutdown is unlikely but possible if decontamination efforts contaminate the facility. Utilities will continue to function, but waste water may be released into rivers for up to one day. ▪ <u>Information/Communications</u> – No shutdown. No major impact on information or communications infrastructure. ▪ <u>Transportation</u> – Delays for less than one day. Some localized road closures will occur, but delays will not be excessive.
RESPONSE CAPACITY	*Critical*	▪ <u>Police</u> – Moderate need for state or federal assistance. Terrorism response automatically triggers federal law enforcement involvement. Sheriff's Office may be needed to support operations. ▪ <u>Fire and Rescue</u> – Significant and long-lasting need for state or federal assistance. EMS resources could experience significant strain. ▪ <u>Health</u> – Critical and long-lasting need for state or federal assistance. Essential HD functions will continue. Non-essential functions will be affected/suspended. PODs will be opened. Special resources need to be called in and there is a possibility that incident-specific response tools may need to be developed. Surge capacity is impacted. ▪ <u>Hospitals</u> – Mutual aid needed. The patient surge would stress the hospital system and would most likely impact neighboring hospitals as well. The Emergency Department would be unable to accept new patients. Incoming patients would be diverted to other facilities. Emergency Department surge would strain the hospital system. ▪ <u>Emergency Management</u> – Mutual aid needed. Support may be necessary to cover the Emergency Management staffing and planning for hazmat cleanup, sheltering efforts, investigation follow-up, and public information coordination. Prolonged planning may necessitate double shifts.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact. Less than a day of clean-up. Impact to a localized area. Release of the agent could lead to limited contamination of air, water and land. A substance that can kill or debilitate humans may also kill or debilitate other animal life in the area. Once the biological agent is removed from the environment, there should be no residual impacts to air, water and land.
ECONOMIC IMPACT	*Significant*	▪ Significant economic output. Other costs include cleanup and healthcare for those affected. ▪ General panic, massive individual flight, and traffic gridlock lead to business closures lasting an indefinite period of time. Business recovery period depends on impact to facilities, staff, and public image.
TOTAL IMPACT[65]	***Catastrophic***	▪ **Total Impact Score: 4 on a scale of 1 (Limited) to 4 (Catastrophic).**

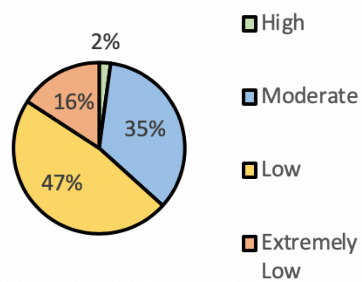
Limited	*Significant*	*Critical*	*Catastrophic*

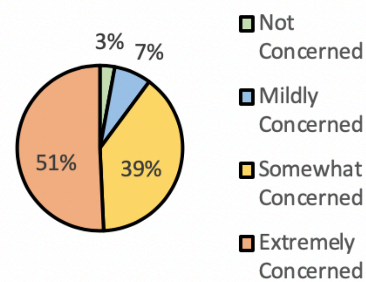
[65] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

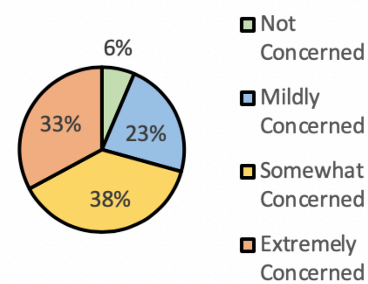
Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

<table>
<tr><th colspan="4">Biological Hazard
Public Perception</th></tr>
<tr><th>PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD</th><th>PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD</th><th>CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY</th><th>CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY</th></tr>
<tr>
<td>

Average: 2.69
Low-Moderate</td>
<td>

Average: 2.23
Low - Moderate</td>
<td>

Average: 3.38
Somewhat Concerned - Extremely Concerned</td>
<td>

Average: 2.97
Mildly Concerned - Somewhat Concerned</td>
</tr>
</table>

Chemical Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

In the 2019 HIRA, Chemical Hazards have been expanded to include all Chemical Hazards, both intentional (Chemical Attacks) and unintentional (Unintentional Chemical Substance Release/Hazmat). Chemical agents are defined by DHS as, "poisonous vapors, aerosols, liquids and solids that have toxic effects on people, animals or plants. While potentially lethal, chemical agents are difficult to deliver in lethal concentrations because they dissipate rapidly outdoors and are difficult to produce."[66]

An intentional Chemical Hazard (Attack) is defined as the "spreading of toxic chemicals with the intent to do harm. A wide variety of chemicals could be made, stolen, or otherwise acquired for use in an attack. Industrial chemical plants or the vehicles used to transport chemicals could also be sabotaged."[67]

Agents used in a Chemical Attack include, "[c]hemical weapons (warfare agents) developed for military use. Toxic industrial and commercial chemicals that are produced, transported, and stored in the making of petroleum, textiles, plastics, fertilizers, paper, foods, pesticides, household cleaners, and other products. [and] chemical toxins of biological origin such as ricin."[68] The effects of a chemical attack may be immediate (within seconds) or delayed (two to 48 hours). Chemical agents are challenging to produce, dissipate rapidly outdoors, and can be difficult to deliver in lethal concentrations. The CDC categorizes hazardous chemicals by exposure effect, including biotoxins, blister agents/vesicants, blood agents, caustics (acids), choking/lung/pulmonary agents, incapacitating agents, long-acting anticoagulants, metals, nerve agents, organic solvents, riot control agents/tear gas, toxic alcohols, and vomiting agents.[69]

An Unintentional Chemical Substance Release/Hazmat hazard occurs when a chemical with the potential to cause harm is accidentally released into the environment. Hazardous materials come in the form of

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[66] Chemical Emergencies. Retrieved from https://www.ready.gov/chemical (last accessed September 19, 2019).
67 National Academies and the U.S. Department of Homeland Security. (n.d.). CHEMICAL ATTACK WARFARE AGENTS, INDUSTRIAL CHEMICALS, AND TOXINS. Retrieved from https://www.dhs.gov/sites/default/files/publications/prep_chemical_fact_sheet.pdf (last accessed September 19, 2019).
[68] National Academies and the U.S. Department of Homeland Security. (n.d.). CHEMICAL ATTACK WARFARE AGENTS, INDUSTRIAL CHEMICALS, AND TOXINS. Retrieved from https://www.dhs.gov/sites/default/files/publications/prep_chemical_fact_sheet.pdf (last accessed September 19, 2019).
[69] CDC. (2018, April 4). CDC | Chemical Emergencies Overview. Retrieved from https://emergency.cdc.gov/chemical/overview.asp (last accessed September 19, 2019).

explosives, flammable and combustible substances, and poisons (biological hazards and radiological hazards are profiled separately).[70] Many hazardous chemicals are used in industry, and accidental exposure to these chemicals may occur if they are not stored correctly, if safety controls malfunction, or if safety procedures are not followed. Hazardous chemicals are also commonly transported by trucks, water, air, and rail[71], and transportation accidents involving hazardous chemicals can result in an unintentional chemical substance release/hazmat hazard.

Risk Profile

The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

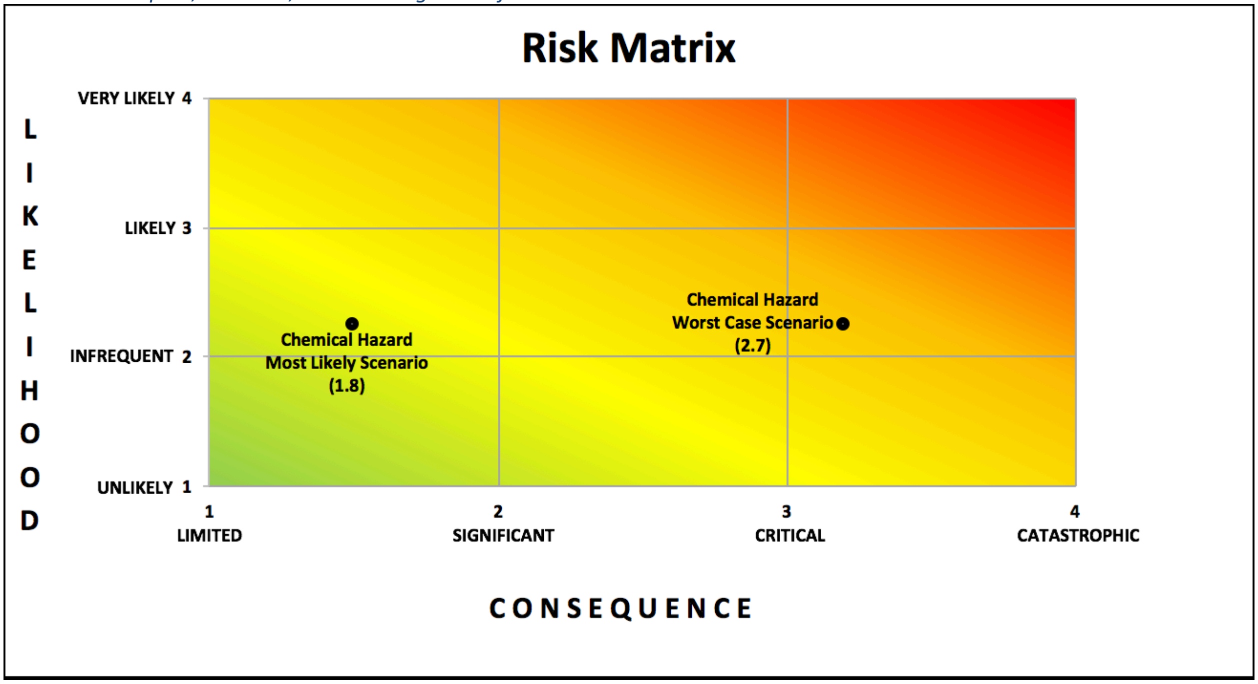
Chemical Hazard Risk Profile				
	Risk Assessment Category	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
LIKELIHOOD	**Likelihood**	2.25 Infrequent-Likely		50%
CONSEQUENCE	**Impact**	1.3 Limited-Significant	3.3 Critical-Catastrophic	40%
	Warning Time	4 Short	4 Short	5%
	Duration	1 Short	2 Moderate	5%
	TOTAL RISK SCORE	**1.8**	**2.7**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

[70] Department of Homeland Security. (n.d.). Hazardous Materials Incidents. Retrieved from https://www.ready.gov/hazardous-materials-incidents (last accessed September 19, 2019).
[71] Read "Cooperative Research for Hazardous Materials Transportation: Defining the Need, Converging on Solutions -- Special Report 283" at NAP.edu. Retrieved from https://www.nap.edu/read/11198/chapter/4 (last accessed September 19, 2019).

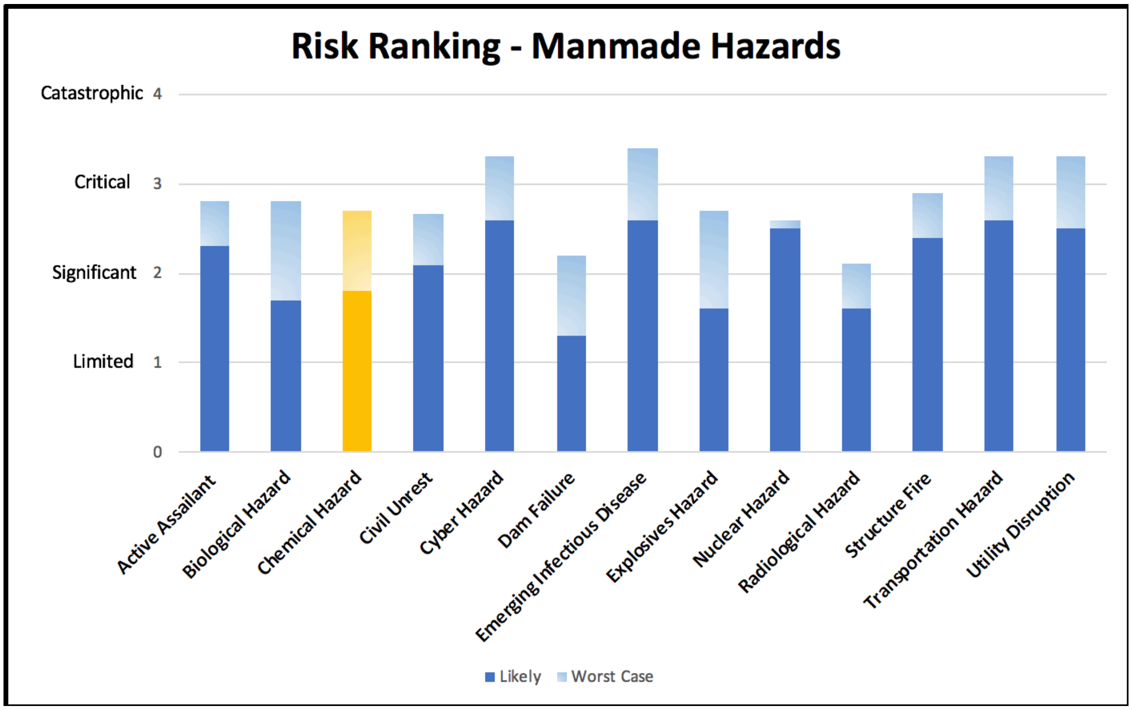
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

During a Chemical Attack, toxic chemical agents could be introduced into the environment through ventilation systems, by aerosolizing devices or sprayers, through chemical-dispersing bombs or explosives, by sabotaging of facilities containing chemicals, or through food and water. Chemical agents used in attacks are frequently directly toxic to humans, and they may also be highly combustible, explosive, or corrosive.[72] However, chemical agents are challenging to produce, usually dissipate rapidly outdoors, and can be difficult to deliver in lethal concentrations.

It is rare to have any advanced warning of a Chemical Attack.

[72] *Chemical Attack: Warfare Agents, Industrial Chemicals, and Toxins,* U.S. Dept. of Homeland Security. Available at http://www.dhs.gov/xlibrary/assets/prep_chemical_fact_sheet.pdf (last accessed September 19, 2019).

The severity of illness associated with a Chemical Attack depends largely on the specific chemical agent and the size of the exposure dose. Many chemical agents result in short-term pain, discomfort, and disorientation. However, inhalation or skin absorption of many chemical agents can cause permanent health problems or death.

Most health effects from a Chemical Attack occur in the minutes immediately following the attack. However, it can be very time consuming to remove some types of chemical hazards from the environment. Certain types of chemicals may continue to be a hazard for days or weeks following the initial attack. Chemical Attacks have the highest likelihood of causing harm if they take place in a closed public space, such as inside an office or onboard public transportation. However, Chemical Attacks can also occur in outside areas, although the risk of a high-dose exposure is much lower.

Hazardous chemicals require special care to remove from the environment. Many chemical hazards can be neutralized using existing hazmat equipment, but in the case of large-scale environmental contamination, equipment needs may extend beyond what is readily available.

The size of the area affected in a Chemical Attack varies depending on the chemical agent and method of delivery. A small-scale chemical release in an enclosed area will expand to fill the enclosed area, while a large attack introducing a chemical into the air or water could impact many square miles. The specific extent of a Chemical Attack hazard may be unknown during the immediate response phase.

An Unintentional Chemical Substance Release/Hazmat hazard can occur in an industrial setting or as the result of a transportation accident. Many hazardous chemicals are used in industry, and accidental exposure to these chemicals may occur if they are not stored correctly, if safety controls malfunction, or if safety procedures are not followed. Hazardous chemicals are also commonly transported by trucks and rail, and transportation accidents involving hazardous chemicals can result in an Unintentional Chemical Substance Release/Hazmat hazard. Hazardous chemicals are even present in a controlled form in many commercial areas, schools, and homes. Hazardous chemicals are frequently directly toxic to humans, and they may also be highly combustible, explosive, or corrosive.**Error! Bookmark not defined.**[,70]

It is rare to have any advanced warning of an Unintentional Chemical Substance Release.

The size of the area affected by an Unintentional Chemical Substance Release depends on the specific chemical agent and the way it was introduced into the environment. A small-scale chemical release may not extend beyond the initial spill area, while a large release that introduces a hazardous chemical into the air or water can impact many square miles. Industrial sites and transportation zones where some of the most hazardous chemicals are found may not be densely populated. However, hazardous chemicals from these incidents can easily reach more populated areas, especially if plumes are spread by the wind or hazardous materials contaminate a water source.

The severity of illness associated with an Unintentional Chemical Substance Release depends greatly on the specific chemical agent and the size of the exposure dose. Many chemical agents result in short-term pain, discomfort, and disorientation. However, inhalation or skin absorption of many chemical agents can cause permanent health problems or death.

Hazardous chemicals require special care to remove from the environment. Many chemical hazards can be neutralized using existing hazmat equipment. However, in the case of large-scale environmental contamination, chemical removal equipment needs may extend beyond what is readily available.

The duration of an Unintentional Chemical Substance Release/Hazmat hazard also depends greatly on the chemical agent involved and the way it was released into the environment. Most health effects from an Unintentional Chemical Substance Release occur in the minutes immediately following the attack. However, it can be extremely time consuming to remove some types of chemical hazards from the environment. Certain types of chemicals may cause a location to be hazardous for days or weeks following the initial attack.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

A Chemical Attack may occur anywhere in Howard County. Likely targets for Chemical Attacks in Howard County include densely populated public areas such as schools, commercial facilities, event venues, and office buildings.

The location of Howard County may increase local vulnerability to Chemical Attacks and other terrorism-related attacks. Howard County is in close proximity to valuable terrorist targets including Washington, D.C., the City of Baltimore, the Port of Baltimore, and BWI Airport. Due to its proximity to the NCR, many Federal agencies, defense contractors, and high-profile targets maintain facilities within Howard County.

Access to toxic chemicals may affect vulnerability to a Chemical Attack. The frequent transport of hazardous chemicals through Howard County increases the likelihood of intentional harmful misuses or manipulation, especially along railroads and major roadways.[73]

Unintentional Chemical Substance Release/Hazmat hazards are most likely to occur in areas where hazardous chemicals are frequently kept or transported. Hazardous chemicals are transported regularly through Howard County, making areas near railways and major roadways particularly vulnerable to Unintentional Chemical Substance Release/Hazmat hazards. Other vulnerable locations in Howard County include areas in close proximity to industrial and research facilities where hazardous chemicals are used.[74]

[73] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).
[74] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

Howard County is home to 141 locations that report the regular use and storage of considerable amounts of hazardous materials, 31 of those sites contain extremely hazardous substances as regulated by the Environmental Protection Agency (EPA). With that number of hazards in the community the likelihood of a disgruntled employee or a deliberate release of a hazardous materials is likely. It is important to note that in the 2015 HIRA, Chemical Hazards were reviewed as two separate hazards, "Chemical Attacks" and "Unintentional Chemical Substance Release/Hazmat". In the 2019 HIRA, Chemical Hazards have been expanded to include all Chemical Hazards, both intentional (Chemical Attacks) and unintentional (Unintentional Chemical Substance Release/ Hazmat). Due to the merging of these hazards, a higher number of the hazard occurrence is being reported as a result of more events falling within the definition of the hazard. The review period for all Chemical Hazard events began in 2004 and continued into 2019. Due to the merging of the hazards, the numbers between 2004-2014 are being labeled as "estimated" numbers, rather than concrete numbers to account for any overlap of reports.

There were five small-scale Chemical Attack hazard events in Howard County between 2004-2019.[75] There have been 478 Unintentional Chemical Substance Release/Hazmat hazard responses involving chemical release, chemical reaction, or toxic conditions in Howard County during the reviewed time period 2008-2019.[76],[77] This totals to an estimated 438 Chemical Hazard events in Howard County from 2004-2019.

<u>Notable Incidents in Howard County</u>

In 2014, there was one chemical attack where Freon was used to sicken a neighbor. This event did not result in loss of life. Additionally, DFRS responded to 11 Confirmed Hazardous Materials Incidents. These do not include the numerous incidents involving carbon monoxide or small gasoline spills.[78]

In 2015, there were no chemical attacks. There was one chemical suicide. However, there were five Confirmed Hazardous Materials Incidents which did not result in any deaths.[79]

In 2016, there were no chemical attacks. However, DFRS responded to 23 Confirmed Hazardous Materials Incidents. These do not include the numerous incidents involving carbon monoxide or small gasoline, motor oil spills.[80]

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[75] While the review period continued until 2019, the data we received from Subject Matter Experts did not include 2019 data.
[76] *Howard County CAD Report 1/01/2008 – 12/31/2013 (unpublished)*, Howard County DFRS (2014).
[77] Howard County Fire Department and Rescue Services, 2019.
[78] Howard County Fire Department and Rescue Services, 2019.
[79] Howard County Fire Department and Rescue Services, 2019.
[80] Howard County Fire Department and Rescue Services, 2019.

In 2017, there were no chemical attacks. However, DFRS responded to eight Confirmed Hazardous Materials Incidents. These do not include the numerous incidents involving carbon monoxide or small gasoline, motor oil spills.[81]

In 2018, there were no reported chemical attacks. However, DFRS responded to nine Confirmed Hazardous Materials Incidents. These do not include the numerous incidents involving carbon monoxide or small gasoline spills.[82]

A large percentage of Unintentional Chemical Substance Release/Hazmat hazard events in Howard County involve hydrocarbon spills such as oil, gasoline, or diesel fuel. Unintentional Chemical Substance Release/Hazmat hazards are also common in a household setting and typically involve the accidental release of mercury or other household chemicals.

Additional information relating to Chemicals within Howard County:

- Number of Tier II facilities[83] in Howard County: 171
- Most common chemicals[84]: Diesel Fuel, Sulfuric Acid, Propane, Anhydrous Ammonia
- Most common compressed gases[85]: Nitrogen, Oxygen, Acetylene, Argon

[81] Howard County Fire Department and Rescue Services, 2019.
[82] Howard County Fire Department and Rescue Services, 2019.
[83] Tier II Facilities are facilities that contain chemicals that are required to be reported by law. Additional information on reporting, including who must report is detailed in 40 CFR § 370.10 and can be found at: https://www.law.cornell.edu/cfr/text/40/370.10. Additional information on what information must be reported is detailed in 40 CFR § 370.30 and can be found at: https://www.law.cornell.edu/cfr/text/40/370.30
[84] The majority of compressed gases and chemicals are either stored for later use or are part of a manufacturing or production process.
[85] The majority of compressed gases and chemicals are either stored for later use or are part of a manufacturing or production process.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Chemical Hazard in Howard County	
Historical Average (time period)	Estimated 483 events between the years (2004-2019).
Historical Annual Probability	30%+ chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	1-30% chance of annual occurrence
Future Likelihood Score[73]	2.25 (Infrequent-Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

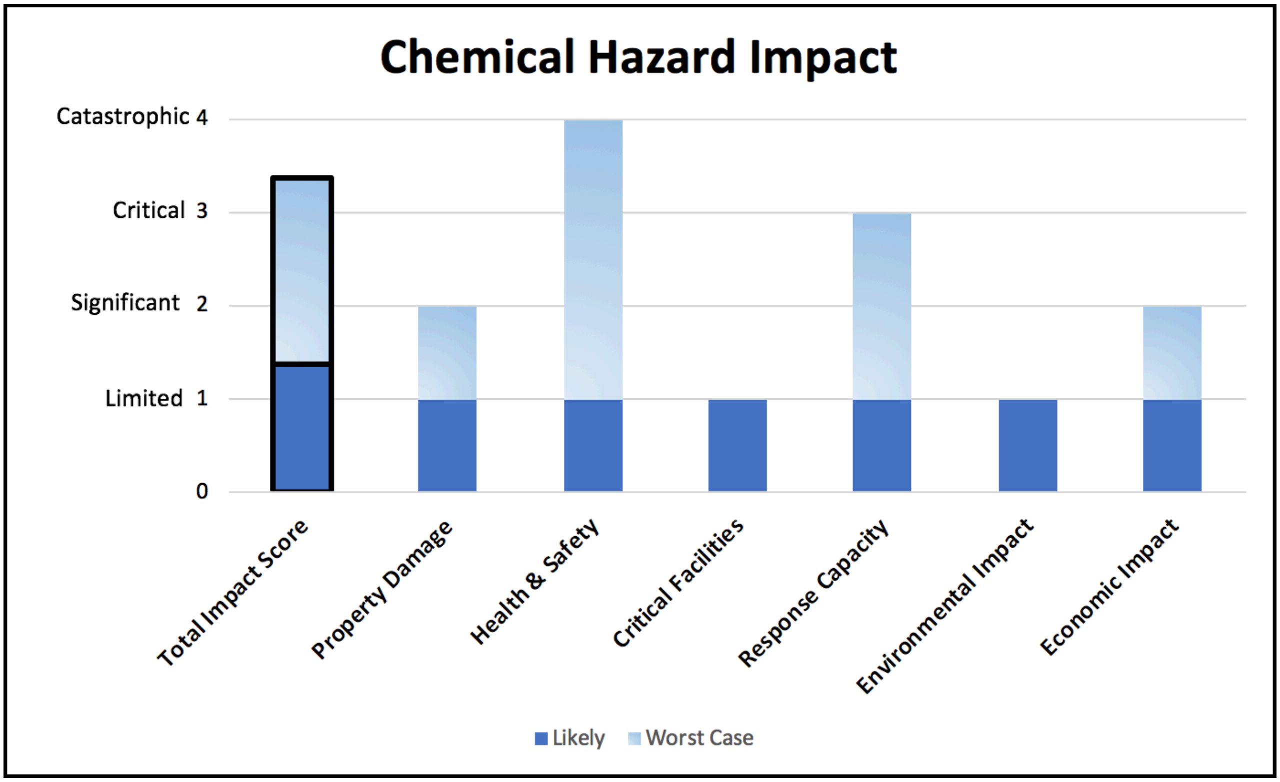
Considerations: The future likelihood of Chemical Hazard in Howard County is expected to change, but not expected to be significantly different from the historical occurrence rate. The future annual probability is 1-30% chance of annual occurrence, or, one event every 3-99 years. Most of the Chemical Attacks that occurred in Howard County have been minor incidents with the exception of one chemical attack in 2014 and one chemical suicide[86] in 2015. Increases in traffic, increases in population, and deterioration of infrastructure will result in a slight increase in likelihood over time.[74] Other considerations include increased availability of chemical products, increase in chemical cases in hospitals, people are more educated regarding these types of chemical attacks, proximity to chemical manufacturing companies, and the frequency of chemicals such as pepper spray being used in robberies.

[86] Chemical suicide is defined by the Department of Human Services as, "Chemical suicides, also called detergent suicides, involve self-inflicted exposure to toxic gases in a confined space (for example, cars, bathrooms, or closets), gases created by mixing consumer products or common household chemicals. This technique appears to have originated in Japan and has since become an increasingly popular method for suicide in the United States and elsewhere after instructions became available online. The two most common toxic gases produced are hydrogen sulfide and hydrogen cyanide." (Citation: Chemical Suicides: The Risk to Emergency Responders - CHEMM. Retrieved from https://chemm.nlm.nih.gov/chemicalsuicide.htm.)

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Chemical Hazard Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time prior to a chemical attack.	*Short.* No warning time prior to a chemical attack.
DURATION	*Short.* One to two hours to remove the hazard.	*Moderate.* Hazard onset is nearly instantaneous. It may take up to 12 hours to declare the hazard location safe.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Chemical Hazard Consequence Analysis Likely				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely.		
HEALTH AND SAFETY	*Limited*	▪ Zero deaths likely. ▪ One to four injuries likely. Injuries will likely affect only those who come into direct contact with the chemical agent.		
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Shutdown unlikely. Impacts to transportation will be minor and short-term.		
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local Resources adequate. ▪ *Fire and Rescue* – Local Resources Adequate. Hazmat Response Team would be unavailable for other responses within the jurisdiction until chemical could be identified. Mutual aid coverage would ensure continuity of operations. ▪ *Health* – Local resources adequate. Essential HD operations will not be affected. ▪ *Hospitals* –Local resources adequate. No impact on the hospital system. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.		
ENVIRONMENTAL IMPACT	*Limited*	▪ No environmental impact. Less than a day of clean-up. Impact to a localized area.		
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. Other costs include cleanup and healthcare for those affected. ▪ Zero jobs lost. ▪ Limited building closure may occur depending on the location of the attack.		
TOTAL IMPACT[87]	***Limited-Significant***	▪ **Total Impact Score: 1.375 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

[87] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

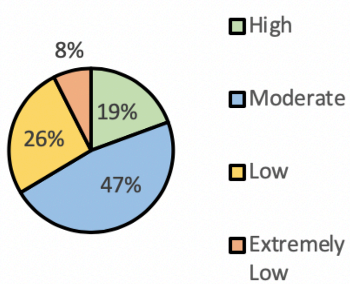
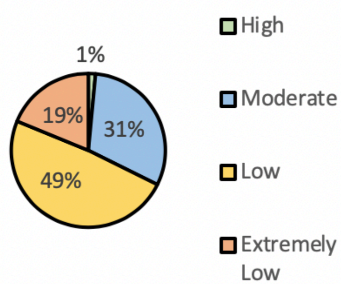
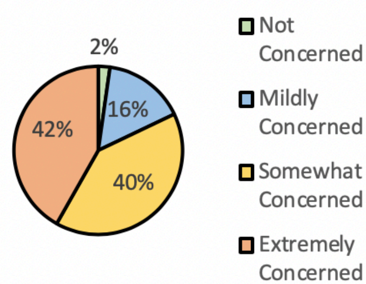
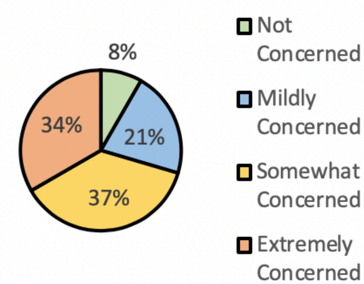
Chemical Hazard Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Significant*	▪ There is damage to critical and non-critical infrastructure of the building where the chemical agent is vaporized. ▪ Repairs/clean-up will be required to deem building safe.
HEALTH AND SAFETY	*Catastrophic*	▪ High death rate for those directly impacted. ▪ Debilitation and disorientation until treated for those who are exposed to lower concentrations.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shut down less than one day. Water treatment facility shutdown is unlikely but possible if decontamination efforts contaminate the facility. ▪ *Information/Communications* – No shutdown. No major impact on information or communications infrastructure. ▪ *Transportation* – Public mobility will be severely impacted, but delays will not last longer than one day.
RESPONSE CAPACITY	*Critical*	▪ *Police* – Significant and long-lasting need for state or federal assistance. Considered a terrorist attack, federal law enforcement would lead the response. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state or federal assistance. There would be long-lasting impact to hazmat response capabilities, and regional EMS resources would be overwhelmed. Significant mutual aid assistance would be required. ▪ *Health* – Significant need for state or federal assistance. Essential HD functions will be impacted. ▪ *Hospitals* – Moderate need for state or federal assistance. Agent-specific medical supplies are likely available at the hospital however, if the attack involves an exotic chemical, additional state and Federal support will be needed. Large turnout of psychological casualties (walking-well). Emergency Department surpasses surge capacity. Normal hospital functions should return to normal in 48 hours. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability. ▪ Special resources needed to respond: Civil support team, federal asset (CST), CBRN Enhanced Response Force Packages (CERF-P), and strategic national stockpile if there is an antidote.
ENVIRONMENTAL IMPACT	*Limited*	▪ If the hazardous area extends outside, air, water, and soil may be contaminated. A chemical that can kill or debilitate humans may also kill or debilitate other animal life in the area. Once the chemical is removed from the environment, there will likely be no residual impacts to air, water and land.
ECONOMIC IMPACT	*Significant*	▪ Significant loss of economic output. Other costs include cleanup and healthcare for those affected. ▪ General panic, massive individual flight, and traffic gridlock lead to business closures lasting an indefinite period of time.
TOTAL IMPACT[88]	***Critical – Catastrophic***	▪ **Total Impact Score: 3.375 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[88] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Chemical Hazard Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
			
Average: 2.78 Low - Moderate	*Average: 2.15 Low - Moderate*	*Average: 3.22 Somewhat Concerned - Extremely Concerned*	*Average: 2.95 Mildly Concerned - Somewhat Concerned*

Civil Unrest

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

Civil Unrest occurs when public disorder has the potential to cause damage or harm. Civil Unrest is often the result of ideological conflict and may include protests, riots, demonstrations, civil disobedience, and other forms of public obstruction. Not all displays of Civil Unrest are Civil Unrest Hazards. Although many expressions of Civil Unrest are safe and legal, a Civil Unrest Hazard occurs when the level of public disorder becomes a threat to health, safety, and property.

Risk Profile

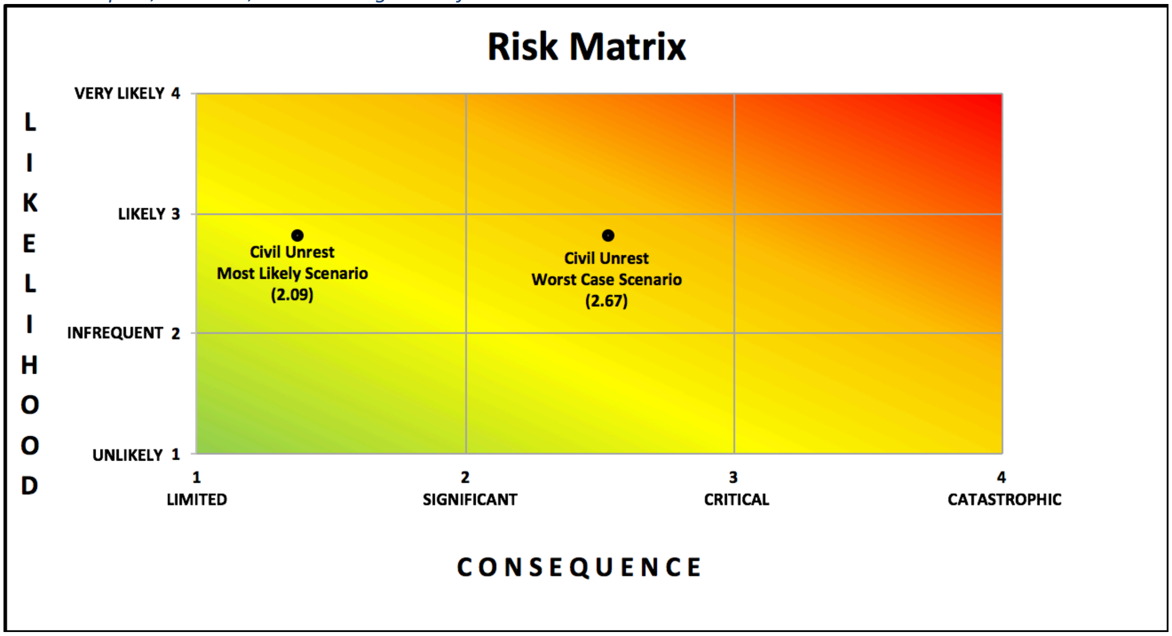
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Civil Unrest Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	2.8 Infrequent-Likely		50%
CONSEQUENCE	**Impact**	1.1 Limited	2.3 Significant-Critical	40%
	Warning Time	4 Short	4 Short	5%
	Duration	1 Short	3 Long	5%
TOTAL RISK SCORE		**2.09**	**2.67**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

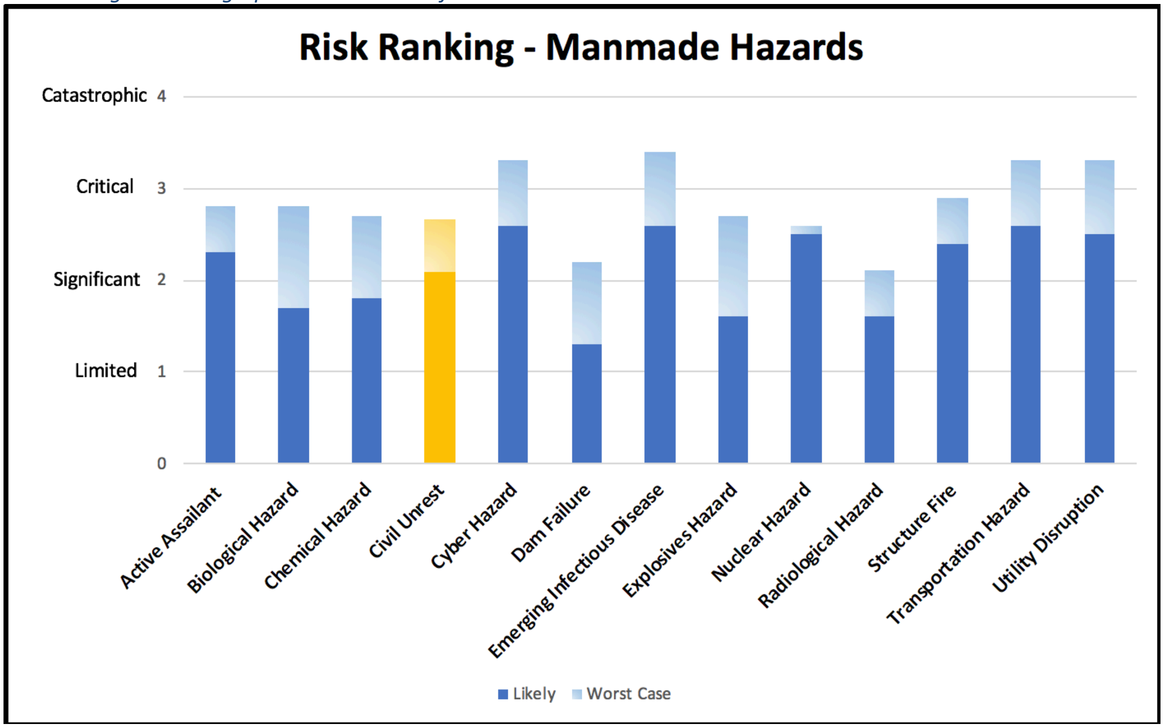
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Civil Unrest may be in the form of a small sit-in, act of civil disobedience, a protest, or a full-scale riot. The intention behind Civil Unrest actions may vary greatly from once incident to another. Many individuals engaged in Civil Unrest wish to peacefully draw media attention, others hope to disrupt traffic or commerce, and still others simply wish to instigate violence. Some instances of Civil Unrest occur without warning, although many times authorities are aware of the potential for a hazard with an advanced warning of one day or more.

The area involved in a Civil Unrest can vary. The area disrupted by a small sit-in can occupy a section of street .25 mile long or smaller. On the other end of the spectrum, a large protest may occupy several miles. Depending on the size of the event, a Civil Unrest hazard may involve anywhere from 1 to 250,000 participants.

The duration of a Civil Unrest Hazard can last one hour to several days. Recovery from a minor incident can take less than one day, while recovery from a major incident can take up to a week to several months. There could be the spreading of incorrect information through the channels of social media, including, but not limited to: Facebook, Twitter, Nextdoor, SnapChat, and Instagram.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Civil Unrest can occur anywhere in Howard County. Many instances of Civil Unrest are the result of social, political, or economic tensions. These hazards are likely to occur in areas with social or political significance. Locations that are vulnerable to Civil Unrest include government buildings, controversial defense or research facilities, locations where historical tensions exist, and locations with a high level of visibility or media attention. Not all instances of Civil Unrest are ideologically based. Civil Unrest may also occur anywhere that people come together, particularly if drugs or alcohol are involved.[89]

[89] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

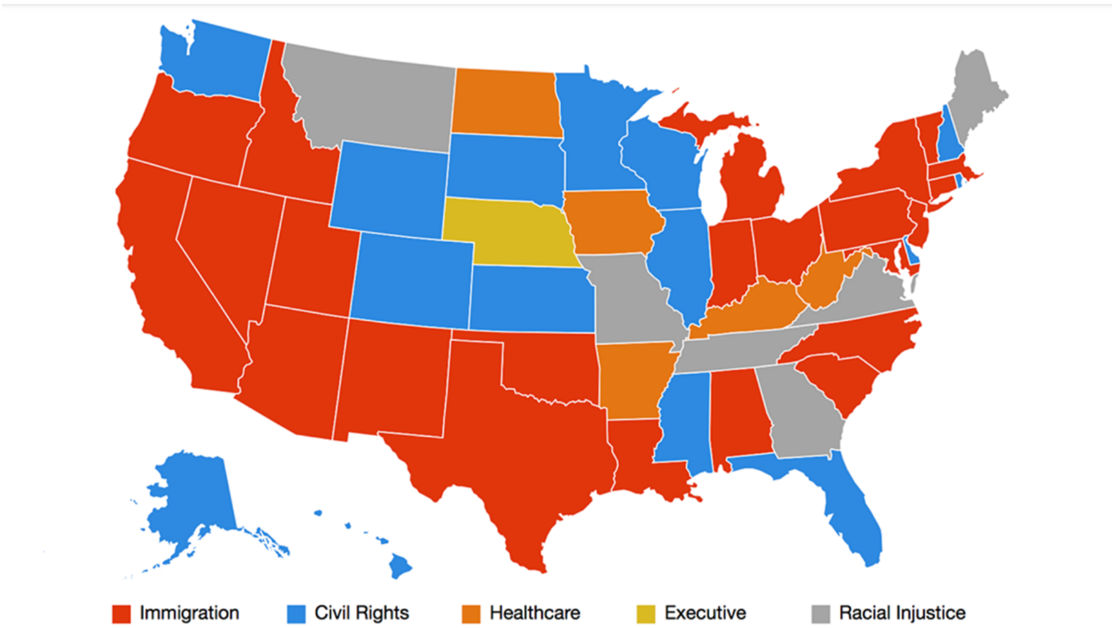
III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

In April 2015 in Baltimore City, there was a Civil Unrest following the death of Freddie Gray who died while in police custody.[90] On April 12th, 2015, in Baltimore, Maryland, "police officers arrested Freddie Gray, an African American man aged 25 years, who sustained neck and spinal injuries while in a police vehicle. His death led to protests citing racism and social injustice. Baltimore erupted in civil unrest: fires, property destruction, and violence. A state of emergency was declared from April 27th until May 6th."[91] Civil Unrest can occur for a multitude of reasons, the graph below demonstrates the most commonly protested issues, by state.



Most Commonly Protested Issues by State [92]

However, there have been zero instances of Civil Unrest in Howard County during the reviewed time period (1996-2019).

[90] Yimgang, D. P., Wang, Y., Paik, G., Hager, E. R., and Black, M. M. (2017). Civil Unrest in the Context of Chronic Community Violence: Impact on Maternal Depressive Symptoms. *American journal of public health*, *107*(9), 1455–1462. doi:10.2105/AJPH.2017.303876

[91] Yimgang, D. P., Wang, Y., Paik, G., Hager, E. R., and Black, M. M. (2017). Civil Unrest in the Context of Chronic Community Violence: Impact on Maternal Depressive Symptoms. *American journal of public health*, *107*(9), 1455–1462. doi:10.2105/AJPH.2017.303876

[92] The data on this graph was collected by "Perkins and Leung by reviewing local media accounts of American protests. Since January 20, 2017, the pair has recorded about 4,296 protests with over 5,402,011 attendees (as of October 11, 2017)." Citation: Leung, T., and Perkins, N. Counting Protests. Retrieved from https://www.bu.edu/articles/2017/counting-american-protests/ Last accessed October 10, 2019).

<u>Notable Incidents in Howard County</u>

Howard County has experienced unruly crowds associated with concerts or gatherings, but none of these situations has escalated beyond control or would be qualified as a Civil Unrest.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

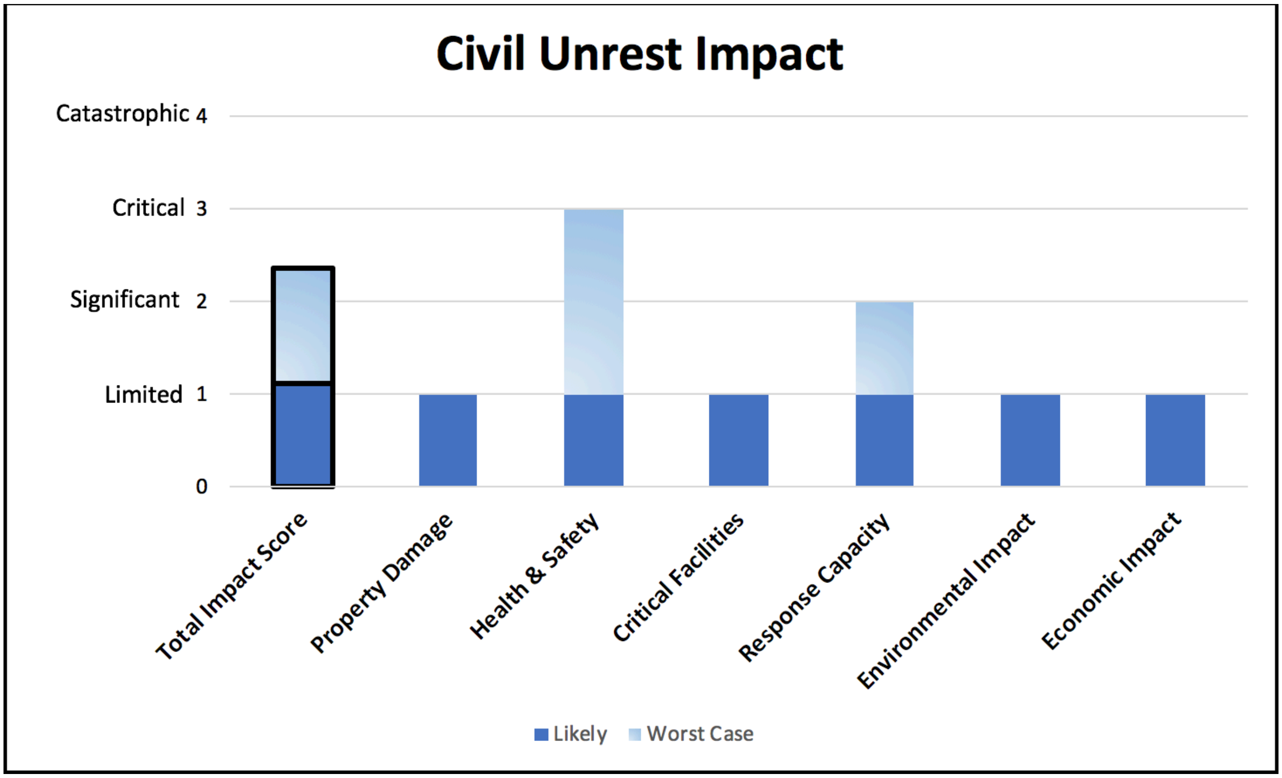
Future Likelihood of a Civil Unrest in Howard County	
Historical Average (time period)	0 recorded events (2000-2019)
Historical Annual Probability	0% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	1-30% chance of annual occurrence
Future Likelihood Score	2.875 (Infrequent- Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: The future likelihood of Civil Unrest in Howard County is expected to be significantly different from the historical occurrence rate. A future annual probability of 1-30% classifies the likelihood of a Civil Unrest as infrequent to likely, or once every 3-99 years. Some factors to consider are societal tension, increased population polarization, increase in media coverage, increased distrust in media, increase in political tension, and the increased use of social media.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Civil Unrest Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* Two to four hours of warning.	*Short.* 15- 20 minutes of warning prior to the Civil Unrest activity reaching hazardous levels.
DURATION	*Short.* Two to three hours to remove the hazard.	*Long.* Two to three days until the hazard is no longer a threat.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Civil Unrest Consequence Analysis
Likely

CATEGORY	RANKING	DESCRIPTION	
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely.	
HEALTH AND SAFETY	*Limited*	Zero deaths likely. ▪ Zero injuries likely.	
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Shutdown unlikely. Impacts to transportation will be minor and short-term.	
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. No impact on response capability or continuity of operations. ▪ *Fire and Rescue* – Local resources adequate. No impact on response capability or continuity of operations. ▪ *Health* – Local resources adequate. HD operations will not be affected. ▪ *Hospitals* – Local resources adequate. No impact on the hospital system. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.	
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact. Less than a day of clean-up. Impact to a localized area.	
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. Other costs include cleanup of the hazard area. ▪ Zero jobs lost. ▪ Minor business disruption in a localized area is possible.	
TOTAL IMPACT[93]	***Limited***	▪ **Total Impact Score: 1.125 on a scale of 1 (Limited) to 4 (Catastrophic).**	
Limited	*Significant*	*Critical*	*Catastrophic*

[93] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

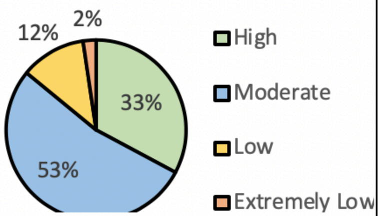
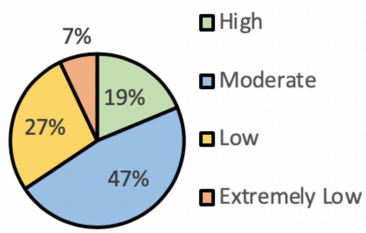
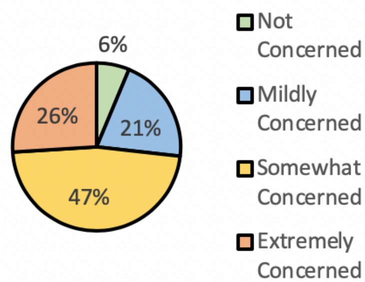
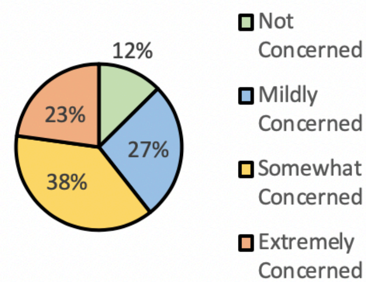
Civil Unrest Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely. Superficial property damage may occur near the site of the Civil Unrest hazard. Damage may include broken glass and localized fires.
HEALTH AND SAFETY	*Critical*	▪ Zero to ten deaths likely. Most deaths and injuries are likely the result of violent altercations or stampeding. ▪ 30-40 injuries likely. Most deaths and injuries are likely the result of violent altercations or stampeding.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Shutdown likely. Impacts to transportation will be localized to the area of the hazard. Traffic delays and road closures will be significant.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Local resources adequate. Road patrol staffing may be slightly depleted. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state or Federal assistance. Minor disruption of response capability. Heavy mutual aid response may be necessary. ▪ *Health* – Local resources adequate. Essential HD operations will not be affected. Emergency Preparedness and Response may be needed to support local response. ▪ *Hospitals* – Local resources adequate. Emergency Department patient surge is expected, but local resources would likely be sufficient. Ambulance traffic may be rerouted, resulting in increased Emergency Department wait times. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact. Impact to a localized area.
ECONOMIC IMPACT	*Limited*	▪ Significant loss in economic output. Other costs include cleanup and healthcare for those affected. ▪ Limited business disruption may occur in the hazard area. County image may suffer.
TOTAL IMPACT[94]	***Limited-Significant***	▪ **Total Impact Score: 2.375 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[94] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Civil Unrest Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
			
Average: 3.16 Moderate - High	*Average: 2.77 Low - Moderate*	*Average: 2.93 Mildly Concerned - Somewhat Concerned*	*Average: 2.71 Mildly Concerned - Somewhat Concerned*

Cyber Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

A Cyber/Communications Infrastructure Attack is an intentional disruption or manipulation of the information and communication systems used to collect, filter, process, create, and distribute data. A Cyber/Communications Infrastructure Attack may seek to impact data or physical infrastructure.

DHS defines a Cyber Security Incident as one that where:

1. Attempts (either failed or successful) to gain unauthorized access to a system or its data;
2. Unwanted disruption or denial of service;
3. The unauthorized use of a system for the processing or storage of data; and,
4. Changes to system hardware, firmware, or software characteristics without the owner's knowledge, instruction, or consent.

Risk Profile

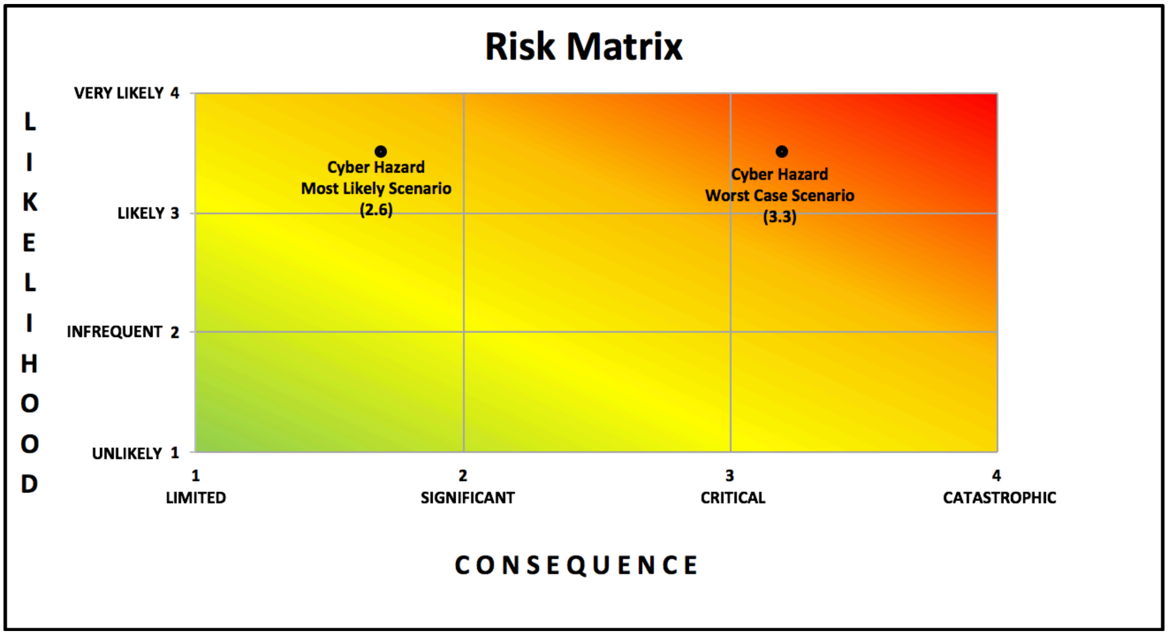
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Cyber Hazard Risk Profile					
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	3.5 Likely-Very Likely		50%
CONSEQUENCE	**Impact**	1.25 Limited-Significant	3 Critical	40%
	Warning Time	4 Short	4 Short	5%
	Duration	3 Long	4 Very Long	5%
TOTAL RISK SCORE		**2.6**	**3.3**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

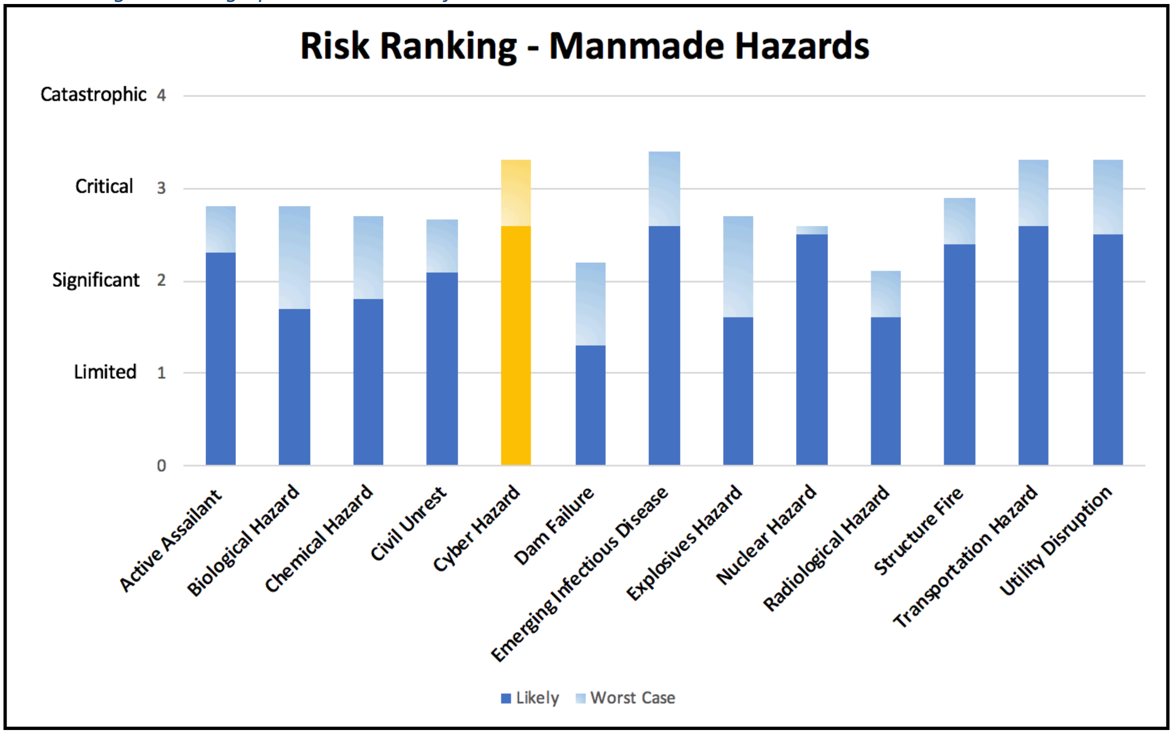
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

A cyber/communications infrastructure attack may seek to impact data or physical infrastructure. Attacks against data compromise the integrity or availability of computerized information or information systems. Attacks against physical infrastructure manipulate computerized information to cause "beyond the computer" harm to people, property, operational capacity, or the environment. Cyber/Communications Infrastructure Attacks commonly target computer software using malicious programs such as viruses, trojan horses, and worms, but may also target hardware through physical attacks on servers, cables, satellites, or communication centers.[95,96] Additionally, cyberattacks:

- "Can use computers, mobile phones, gaming systems, and other devices
- Can include identity theft
- Can block your access or delete your personal documents and pictures
- Can target children and
- Can cause problems with business services, transportation, and power"[97]

A smaller-scale Cyber/Communications Infrastructure Attack may target individually owned devices such as computers or mobile phones. Attacks that are larger in scale can disrupt transportation, power, other services, or seek to access private information from government and commercial networks. Depending on the scope of the attack, Cyber/Communications Infrastructure Attack hazards can impact anywhere from a single computer to data networks spreading across the entire country.

Some Cyber/Communications Infrastructure Attacks may seek to gain access to private information for the purpose of espionage or identity theft. Other attacks wish to alter data for personal, financial, or political gain. Still other attacks use cyber tactics as a mechanism to cause social disruption or cause fear. Cyber/Communications Infrastructure Attacks can also be used as a mechanism to create physical consequences, such as the manipulation or disruption of traffic lights, gas line pressure systems, or radio and 911 call center communications.

With ample control systems and business services being used and/or managed via the internet, the typical Cyber Security attack could range from a single computer being infected with a virus to the County's entire data center being taken offline due to a hacker taking control of network services. Additionally, while

[95] Department of Homeland Security. Cybersecurity. Retrieved from https://www.ready.gov/cybersecurity (Last accessed September 20, 2019).

[96] For additional information see *Strategic National Risk Assessment,* U.S. Dept. of Homeland Security (2011). Available at http://www.dhs.gov/xlibrary/assets/rma-strategic-national-risk-assessment-ppd8.pdf (last accessed September 20, 2019).

97 Department of Homeland Security. (n.d.). Cybersecurity. Retrieved from https://www.ready.gov/cybersecurity (Last accessed September 20, 2019).

Howard County may not be the specific target of this type of attack, an attack on a cloud services provider used by the County could impact a broad range of services used by the County including email, Information Technology (IT) Security, IT Service Management, Constituent Management, Payroll, utility payment processing, electronic traffic signs, computer controlled environmental systems, and etc.

While most cyber-security events are malicious in nature with specific intent to negatively impact services ('hacktivisim') or impact services for financial gain (typically ransomware), there are cases where a data breach via end user negligence could lead to other challenges for the County. While very rare, these challenges include things such as reputational impacts or in very severe cases, election tampering. Regardless of the intent and attack vector, the scope of impact from a cyber-attack will vary greatly depending upon an attacker's intent and the impacted systems.

A Cyber Security attack could impact a single user to County-wide services impacting both visitors and constituents. For example, electronic road signs are updated to state a road closure and recommend traffic diversion to a different route, creating unnecessary congestion which impacts public safety.

Typically, there is no advance warning of a cyber-security event and any evidence of an event in motion is usually negated by the speed at which malware, ransomware, or other malicious events can replicate themselves would negate any awareness of an event in motion. In very rare occurrences, during a specifically targeted attack, victims are made aware of an infiltration (usually with proof) and a demand for payment in order to prevent any further infiltration. These are very rare and tend to be targeted in nature.

Depending upon the type of Cyber Security event, the duration of the event can range from a few hours to several months to stop the spread and to recover the technology from the impact. Depending upon the source, type, and impact, of the event, the on-going reputational impacts or follow on regulatory audits (ex. in the case of a Health Insurance Portability and Accountability Act (HIPAA) breach) could tie up County engineering resources for months beyond the end of the event.

While the depth and breadth of Cyber Security events can vary quite broadly, the most probable types of events and their effects are listed below:

- Malware infection on an end-user computer causing:
  - The user's inability to perform their duties. Impact will vary depending upon role of the user.
  - Public safety should not be overly impacted as Computer Aided Dispatch (CAD) workstations do not have internet access and are tightly controlled.
  - The malware could spread laterally ("east-west") infecting "neighboring" computers and or/servers.
- Servers/systems either significantly behind in patches or completely unpatched due to operating system patches breaking application functionality.
  - This is most likely within control systems as environmental controls, such as System Control and Data Acquisition (SCADA) systems.

- Control systems may not have direct internet access but can be adjacent in the network to systems that do.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

A Cyber Hazard may occur anywhere that relies on electronic information and communications systems, and all of Howard County is susceptible to the effects of this attack. Vulnerability to the consequences of a Cyber Hazard increases as essential functions become increasingly reliant on electronic information and communications systems. Possible targets for Cyber Hazards in Howard County include government communications networks, databases containing sensitive personal information, and SCADA systems that monitor and control industrial processes.[98]

[98] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

On a national level, in the first six months of 2019, “there were more than 3,800 reported data breaches—a 54% increase from the same period last year—exposing more than 4.1 billion records. The average reported cost of a data breach for an American company is $8.2 million.”[99]

Furthermore, “the Privacy Rights Clearinghouse reports that in 2018 there were 1,366,471,618 records held by various organizations in the U.S. that were breached. In 2017, the number of breached records was higher: 2,048,395,688.”[100] Cyberattacks have increased “300% during the first quarter of 2016 compared to all of 2015.”[101]

In Maryland, “the Office of the Maryland Attorney General reports that in Fiscal Year 2016 alone there were 564 data breaches affecting more than 600,000 Maryland residents. The breaches were due to phishing, retail malware, lost or stolen laptops or other devices, unauthorized access, and inadvertent administrative error, such as mistakenly sending personal identifying information to third parties not authorized to have it.”[102] In Fiscal Year 2018, there were “4,049,531 reported cases of Maryland residents being affected by a breach.”[103]

FY 2018 Maryland Breach Snapshot[104]

Type of Personal Information Lost or Exposed	Total Maryland Residents Reported As Affected in Breach Notes	# Organizations Involved
Full social security number with a least name	3,575,046	446
Payment card information with other personal identifying information	140,807	193
Bank account number or other banking information with other personal identifying information	10,349	41

[99] Davis, J. M., and Dlatt, B. H. How to prepare yourself and your clients to respond to data breaches. Retrieved from http://www.abajournal.com/voice/article/how-you-and-your-clients-can-be-ready-for-and-respond-to-a-data-breach?utm_source=msba weeklyandutm_medium=email (last accessed September 24, 2019).
[100] MARYLAND CYBERSECURITY COUNCIL ACTIVITIES REPORT 2017 - 2019 . (2019, July 1). Retrieved from https://www.umuc.edu/documents/upload/maryland-cybersecurity-council-activities-report-2017-2019.pdf (Last accessed September 20, 2019). Citing: See Privacy Rights Clearinghouse at https://www.privacyrights.org/. The data reported here results from queries involving all breach types and all organizations.
101 FEMA. Cybersecurity. Retrieved from https://www.fema.gov/cybersecurity (Last accessed September 20, 2019).
[102] Maryland Cybersecurity Council Activities Report. (2017, January). Retrieved from http://www.marylandattorneygeneral.gov/Reports/Maryland_Cybersecurity_Report.pdf (Last accessed September 20, 2019).
[103] MARYLAND CYBERSECURITY COUNCIL ACTIVITIES REPORT 2017 - 2019 . (2019, July 1). Retrieved from https://www.umuc.edu/documents/upload/maryland-cybersecurity-council-activities-report-2017-2019.pdf (Last accessed September 20, 2019).
104 MARYLAND CYBERSECURITY COUNCIL ACTIVITIES REPORT 2017 - 2019 . (2019, July 1). Retrieved from https://www.umuc.edu/documents/upload/maryland-cybersecurity-council-activities-report-2017-2019.pdf (Last accessed September 20, 2019).

Medical or treatment information with other personal identifying information	65,337	70

There has never been a successful emergency-level Cyber Hazard in Howard County (an emergency-level Cyber/Communications Infrastructure Attack is an incident that requires a multi-agency response). However, everyday Howard County experiences multiple Cyber threats that do not amount to a successful emergency-level Cyber Hazards. There have been approximately six emergency-level Unintentional Cyber/Communications Infrastructure Failure Hazards in Howard County during the reviewed time period (2009-2019).

For Howard County, it is estimated that these actions may be the result of, or the catalyst to:

1. Malware/Ransomware inadvertently or intentionally released on County Personal Computer (PCs) and/or servers.
2. Denial of access either to publicly available web functions such as utility payments and other County services or services provided by the County that are delivered via telephone up to and including 911.
3. Infiltrating our network perimeter and gaining access to computer servers, desktops, and/or, environmental control systems.

Notable Incidents in Howard County

General phishing attacks, searches for protected data, and system exploits allowing the entry of harmful software may take place thousands of times each day. These attacks most commonly result in the release of protected information or cause damage to individual software and hardware.

2010 Public Safety Answering Point (PSAP) Outage – While relocating the PSAP, PSAP communications lines were severed unintentionally. Howard County citizens were unable to reach the PSAP until calls were successfully rerouted to a backup call center 45 minutes later. Essential PSAP functions were carried out by the backup call center, but several days passed before Howard County PSAP infrastructure was restored.

2012 Radio Systems Outage – Equipment on a radio tower became damaged in high winds. The damage created radio dead spots in the tower area. Nearly one week passed before the damage was entirely repaired.

2013 Trojan Attack – A trojan was placed in the Howard County network that allowed access to protected information and caused data damage to a large portion of the County network. The trojan was identified, and data was restored from backup. Although it was quickly stopped, this hazard had the potential to cause significant damage if unchecked.

2013 Radio Systems Outage – While completing regular maintenance on the power supply, a radio tower was taken offline. Emergency response organizations in that tower area lost ability to communicate by radio (roughly 10% of Howard County). Police and DFRS were forced to use alternate communications methods. Radio was restored in less than two hours.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

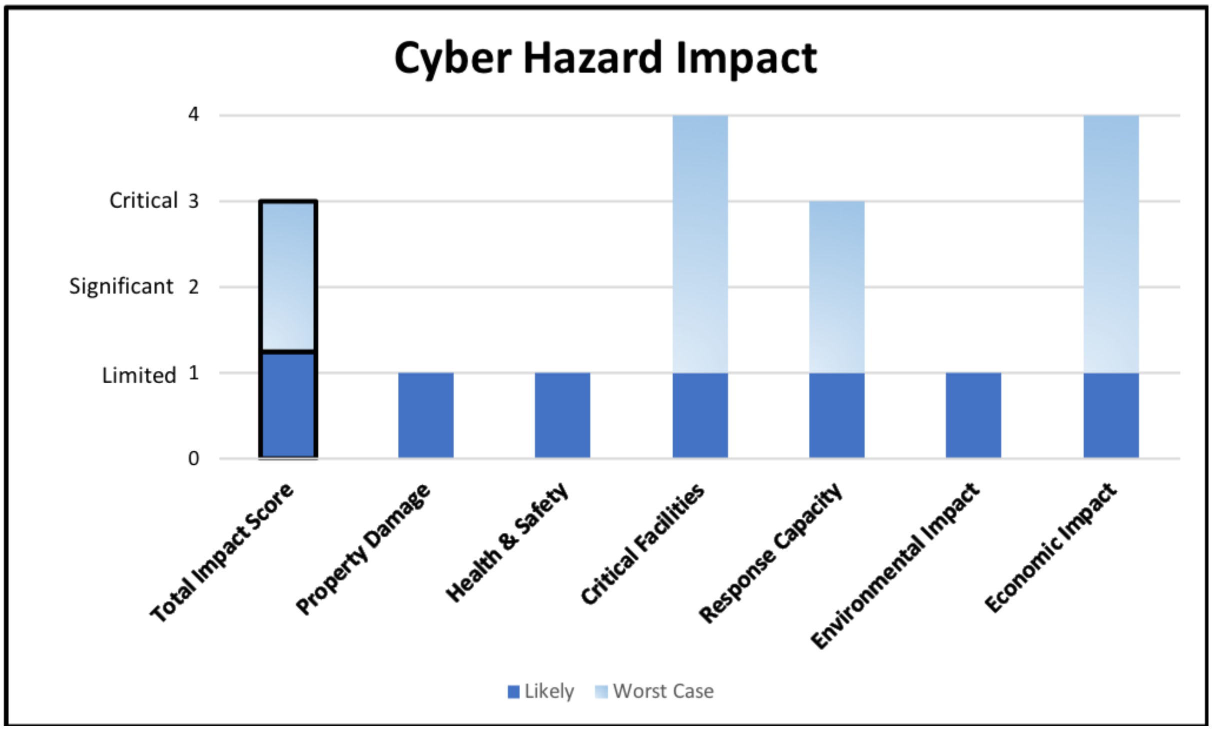
Future Likelihood of a Cyber Hazard in Howard County	
Historical Average (time period)	Approximately 1.6 events every year (2009-2019)
Historical Annual Probability	30% + chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	11- 30% + chance of annual occurrence
Future Likelihood Score	3.5 (Likely- Very Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: Likelihood estimates for an emergency-level attack have a wide range of variability. A future annual probability of 11- 30% + classifies the likelihood of a Cyber Hazard as Likely to Very Likely, or alternatively one event every 3-9 years. Howard County has never experienced a successful emergency-level Cyber Hazard, but several factors contribute to the expected increase in likelihood. There are several cyber firms, government security contractors, offsite intel Sensitive Compartmented Information Facilities, and other potential targets within the County. Rapid advances in technology and a growing number of parties interested in data-gathering or system-damaging attacks contribute to the increased likelihood of an emergency-level Cyber Hazard. Likewise, the likelihood of an attack increases as Howard County increases its reliance on electronic information systems. Additionally, online tutorials for hacking are more prevalent. Hacking events are also increasing in drastic numbers both state-wide and nationally.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Cyber Hazard Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* A few minutes to a few hours.	*Short.* No warning time prior to an attack.
DURATION	*Long.* One to two hours to replace each infected PC and up to two days to recover documents/ files from infected PC.	*Very Long.* 36 hours to restore network and communications functions and begin restoring water. It takes four days to restore all systems. It takes four to six months for all those impacted to upgrade their cybersecurity systems.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Cyber Hazard **Consequence Analysis** **Likely**				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Damage to buildings and structures is unlikely. ▪ User's PC is impacted due to phishing email.		
HEALTH AND SAFETY	*Limited*	▪ Deaths are very unlikely. ▪ Injuries are very unlikely.		
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely or very short in duration. Little to no impact on water supply and waste water systems. Systems can be restored manually within hours. ▪ *Information/Communications* – Little to no shutdown for nearly all users. A small number of individual users (fewer than five) may lose access to networks or hardware. ▪ *Transportation* – Shutdown unlikely. Transportation routes will not be impacted.		
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. If the nature of the Cyber Attack necessitates a terrorism response, Federal law enforcement involvement will be triggered automatically. ▪ *Fire and Rescue* – Local resources adequate. ▪ *Health* – Local resources adequate. HD may experience temporary service disruptions for a small number of users. ▪ *Hospitals* – Local resources adequate. Provided that water supply is not affected, hospital operations will not be affected. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.		
ENVIRONMENTAL IMPACT	*Limited*	▪ No environmental impact, provided that the communications infrastructure outage does not result in any industrial or wastewater treatment plant discharges or spills.		
ECONOMIC IMPACT	*Limited*	▪ Lost productivity, job duties not performed could have downstream impacts depending upon employee's role. ▪ Services for the day, including ability to receive and send emails are impacted.		
TOTAL IMPACT[105]	***Limited***	▪ **Total Impact Score: 1.25 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

[105] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

Cyber Hazard Consequence Analysis
Worst-Case

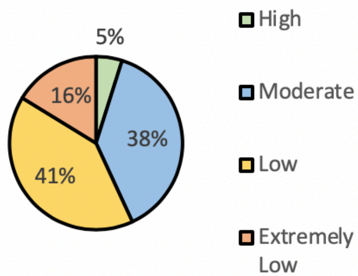
CATEGORY	RANKING	DESCRIPTION
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Damage to buildings and structures is unlikely.
HEALTH AND SAFETY	*Limited*	▪ Zero deaths likely. ▪ Zero injuries likely. ▪ Although direct deaths and injuries are unlikely, those that occur are likely due to cascade effects (indirect consequences of the hazard). In the event of a Cyber Attack targeting power or utilities infrastructure, hospitals may be unable to provide essential services.
CRITICAL FACILITIES	*Catastrophic*	▪ *Utilities* – Shutdown for up to 36 hours in the entire County. Water supply and waste water treatment will be shut down for several hours. It takes four days to restore all systems. It takes four to six months for all those impacted to upgrade their cybersecurity systems. ▪ *Information/Communications* – Shutdown for 36 hours. Email systems and access to internet may be unavailable. Voice Over Internet Phone (VoIP) systems will be offline, but cell phones will likely remain operational. ▪ *Transportation* –The attack targeted traffic control systems causing significant transportation delays.
RESPONSE CAPACITY	*Critical*	▪ *Police* – Mutual aid needed. If the nature of the Cyber/Communications Infrastructure Attack necessitates a terrorism response, federal law enforcement involvement will be triggered automatically. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state or federal assistance. If attacks target infrastructure, fire/rescue resources may be significantly strained by efforts to support the restoration of services. ▪ *Health* – Moderate need for state or federal assistance. HD operations could be disrupted. ▪ *Hospitals* – Significant need for state or federal assistance. A network/internet outage would cause most hospitals services to be unavailable. Basic patient treatment could continue, but support services would be unavailable. Evacuation may be necessary, and hospital services would be constrained to limited stabilization. ▪ *Emergency Management* – Local resources adequate. Continuity of Operations (COOP) plans would be activated.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact, provided that the communications infrastructure outage does not result in any industrial or wastewater treatment plant discharges or spills. Prolonged outage of communications systems may result in delays for some environmental protection services, and the extent of secondary environmental consequences is difficult to predict.
ECONOMIC IMPACT	*Catastrophic*	▪ Significant loss in economic output and many jobs lost. Other costs include cleanup and healthcare for those affected. All business will likely cease for several days. Serious damage may occur to the reputation of Howard County infrastructure.
TOTAL IMPACT[106]	***Critical***	▪ **Total Impact Score: 3 on a scale of 1 (Limited) to 4 (Catastrophic).**

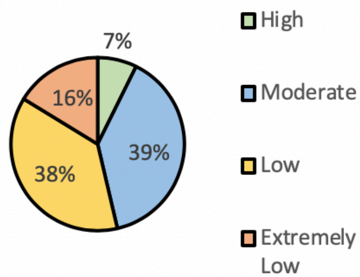
Limited	*Significant*	*Critical*	*Catastrophic*

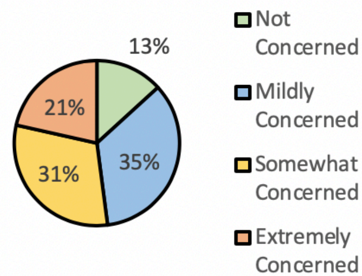
[106] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

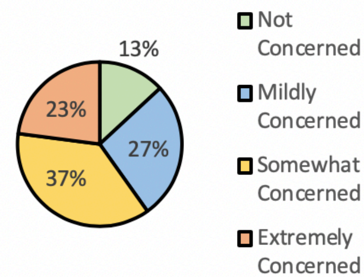
Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

<table>
<tr><th colspan="4">Cyber Hazard
Public Perception</th></tr>
<tr><th>PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD</th><th>PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD</th><th>CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY</th><th>CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY</th></tr>
<tr>
<td>

Average: 2.32
Low - Moderate</td>
<td>

Average: 2.37
Low - Moderate</td>
<td>

Average: 2.60
Mildly Concerned - Somewhat Concerned</td>
<td>

Average: 2.70
Mildly Concerned - Somewhat Concerned</td>
</tr>
</table>

Dam Failure

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

The Code of Maryland Regulations (COMAR) defines a "dam" as "any obstruction, wall or embankment together with its abutments and appurtenant works built for the purpose of storing or diverting water."[107]

A Dam Failure occurs when some or all of a dam's water-retaining barrier becomes damaged causing the uncontrolled release of water downstream and can lead to rapid flooding of downstream land. A Dam Failure can be the result of a design or construction error, insufficient maintenance, human error, or internal erosion. Dam Failures can also occur as the result of an intentional attack or as a cascading effect of natural hazards such as flooding, earthquakes, or geological instability.

[107] Maryland Department of the Environment. Maryland's Dam Safety Program. Available at https://mde.maryland.gov/programs/Water/DamSafety/Documents/FactSheetHazardClassificationsofDams.pdf (last accessed September 24, 2019).

Risk Profile

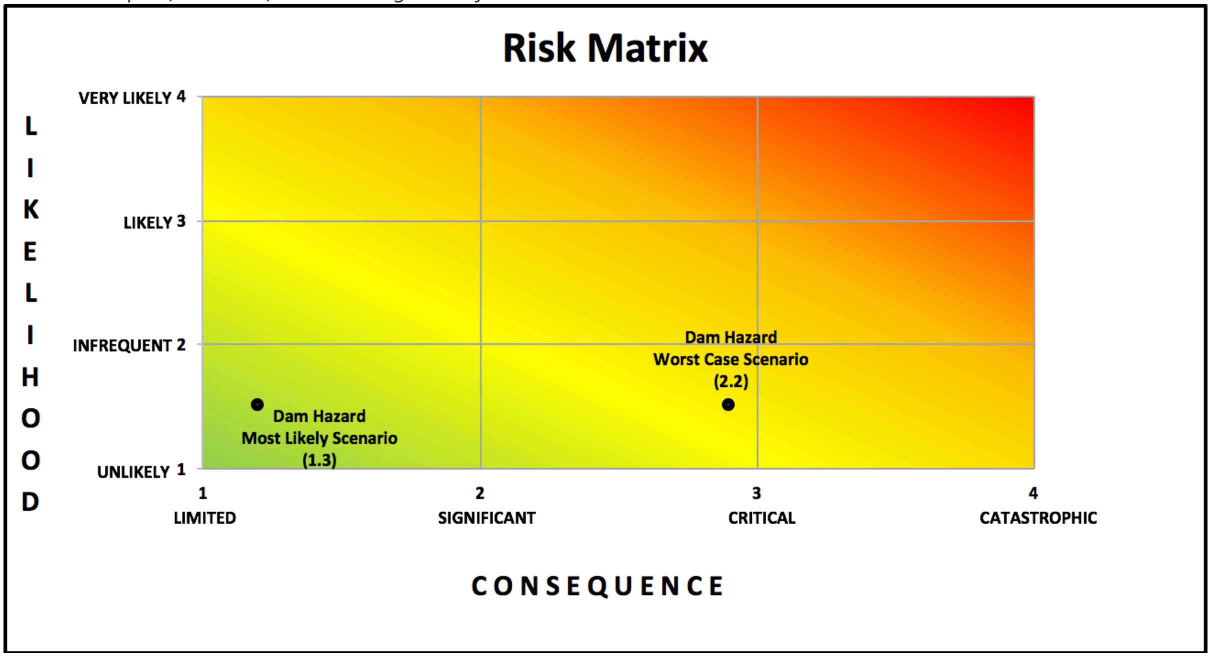
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Dam Failure Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	1.5 Unlikely-Infrequent		50%
CONSEQUENCE	**Impact**	1.1 Limited	2.7 Significant-Critical	40%
	Warning Time	3 Moderate	4 Short	5%
	Duration	1 Short	4 Very Long	5%
TOTAL RISK SCORE		**1.3**	**2.2**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

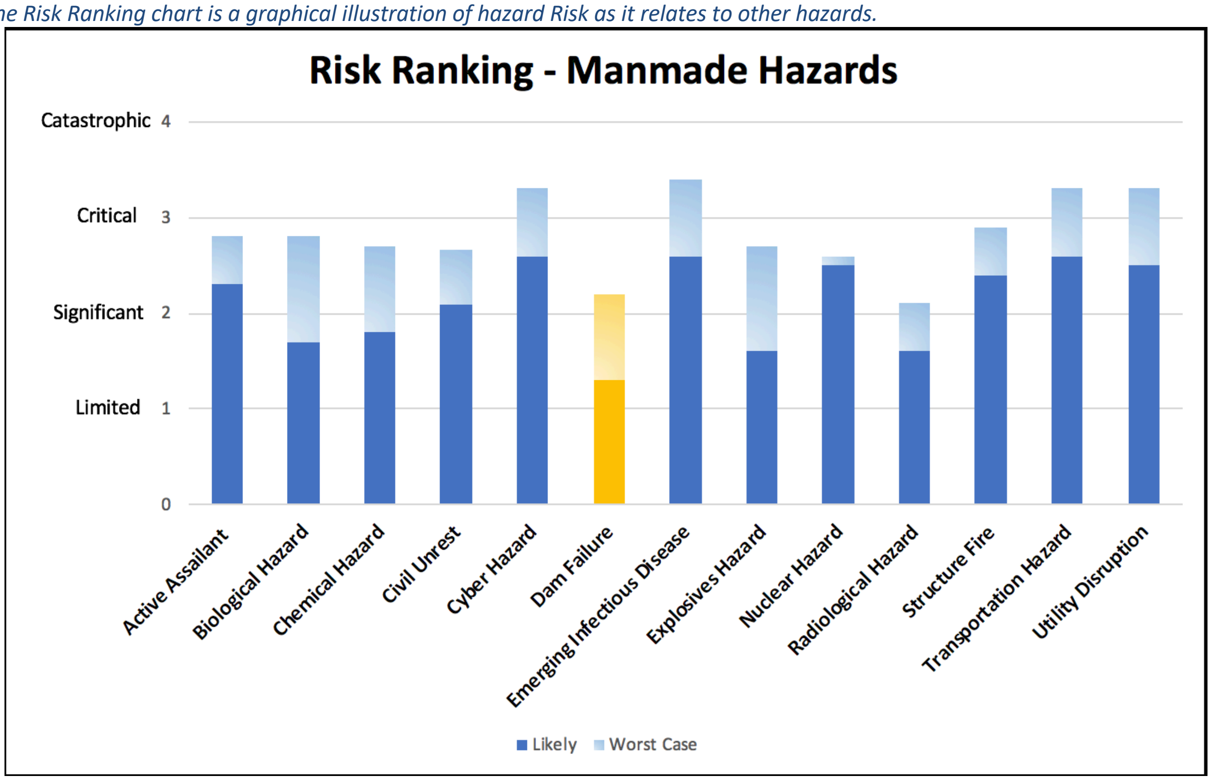
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

The Maryland Department of the Environment classifies dams as follows:

- High Hazard Dams: "Failure would likely result in loss of human life, extensive property damage to homes and other structures, or cause flooding of major highways such as state roads or interstates. High Hazard dams are referred to as 'Category I' dams in COMAR (26.17.04.05) and 'Class C' ponds by the US Natural Resources Conservation Service (NRCS)."[108]
- Significant Hazard Dams: "Failure could possibly result in loss of life or increase flood risks to roads and buildings, with no more than two houses impacted and less than six lives in jeopardy. These are referred to as 'Category II' dams in COMAR and 'Class B' by NRCS."[109]
- Low Hazard Dams: "Failure is unlikely to result in loss of life and only minor increases to existing flood levels at roads and buildings is expected. These structures are referred to as 'Category III' dams in COMAR and 'Class A' by NRCS."[110]

Dam Failure can occur regardless of the type of dam or size of the body of water. Large dams can be complex structures reaching hundreds of feet into the air. Small earthen dams retaining ponds and streams can also pose a threat.

The consequences of a Dam Failure are dependent on the size of the body of water, the location of the dam, and the characteristics of the downstream floodplain. A minor failure of a Low Hazard dam may only result in minor increases to existing flood levels. However, the failure of a High Hazard dam may result in rapid increases in existing flood levels for several miles along downstream rivers and floodplains. A minor Dam Failure may wash out into small streams or fields and never impact any populated area. However, a major Dam Failure may greatly increase flood levels at houses, buildings, and major interstates, state, and County roads. Signs of imminent Dam Failure due to flash flooding or structural defects may occur over the span of several hours and can provide a brief window of warning time prior to the release of water. On some occasions a Dam Failure or breach can occur with days or weeks of warning time as a result of slow debris jams or slow-onset flooding, provided the warning signs are acknowledged as such.

[108] Maryland Department of the Environment. Maryland's Dam Safety Program. Available at https://mde.maryland.gov/programs/Water/DamSafety/Documents/FactSheetHazardClassificationsofDams.pdf (last accessed September 24, 2019).
[109] Maryland Department of the Environment. Maryland's Dam Safety Program. Available at https://mde.maryland.gov/programs/Water/DamSafety/Documents/FactSheetHazardClassificationsofDams.pdf (last accessed September 24, 2019).
[110] Maryland Department of the Environment. Maryland's Dam Safety Program. Available at https://mde.maryland.gov/programs/Water/DamSafety/Documents/FactSheetHazardClassificationsofDams.pdf (last accessed September 24, 2019).

Dam Failures can occur suddenly or gradually. A sudden Dam Failure occurs instantaneously with a forward shockwave travelling rapidly downstream. Gradual Dam Failures may take anywhere from 15 minutes to 24 hours to release the excess water in the form of a gradual flow.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Dam Failures can occur anywhere that dams exist. Howard County has over 2,000 small earthen dams on ponds, streams, and minor bodies of water.[111,112] Most of the recognized dams in Howard County are relatively small earthen impoundments created for either flood control or recreation. However, the Columbia Gateway Dam, the Centennial Park Dam, Holly House Meadows Dam, Lake Elkhorn, and the Oakhurst Section 1 Dam are classified as high hazard dams. An additional 21 dams are classified as Significant Hazard dams.

Notable Dams in Howard County	
HIGH HAZARD DAMS	
Centennial Park Dam (MD Dam #284)	▪ Location: Centennial Lake, approximately one mile from the intersection of US Route 29 and MD Route 108 (Lat: 39.242073; Long: -76.858048) ▪ Height: 39.5 ft. ▪ Built: 1985 ▪ Drainage Area: 3.48 sq. mi.
Columbia Gateway Dam (MD Dam #75)	▪ Location: Above Samuel Morse Drive, approximately ¼ mile from the intersection of Columbia Gateway Drive (Lat: 39.170898; Long: -76.809161) ▪ Height: 32 ft. ▪ Built: 1970 ▪ Drainage Area: 1.5 sq. mi.
Holly House Meadows Dam (Dam # 480)	▪ Location: North of the intersection of Lime Kiln and Reservoir Road (Lat: 39.148639; Long: -76.940389) ▪ Height: 20.2 ▪ Built: 1983 ▪ Drainage Area: 64.3 Ac
Lake Elkhorn Dam (MD Dam #125)	▪ Location: Lake Elkhorn, approximately ¾ of a mile north of the intersection of MD Routes 32 and Broken Land Parkway (Lat: 39.10560; Long: -77.14860) ▪ Height: 32 ft. ▪ Built: 1974 ▪ Drainage Area: 3.7 sq. mi.
Oakhurst Section SWM Dam	▪ Location: Approximately 300' north of the intersection of Guilford Road and Oakhurst Drive (Lat: 39.164139; Long: -76.829028)

[111] For additional information see *2018 Flood Mitigation Plan* Update, Howard County Dept. of Public Works (2018, October 1). Available at https://www.howardcountymd.gov/LinkClick.aspx?fileticket=4746kpy1PBM=andportalid=0 (last accessed September 2019).

[112] *Emergency Action Plan: High and Significant Hazard Dams in Howard County,* Howard County Stormwater Management Division/Columbia Association (2012).

Notable Dams in Howard County	
(MD Dam #437)	▪ Height: 12 ▪ Built: 1997 ▪ Drainage Area: 41.4 Ac
Diversified Lane (MD Dam #590)	▪ Location: Northeast of the intersection of Diversified Lane and Gudel Drive (Lat: 39.30384; Long: -76.85241) ▪ Height: 8.3 ft. ▪ Built: 1992 ▪ Drainage Area: 0.02 sq. mi.
SIGNIFICANT HAZARD DAMS	
Wilde Lake Dam (MD Dam #51)	▪ Location: Wilde Lake, west of Little Patuxent Parkway (Lat: 39.22325; Long: -76.85929) ▪ Height: 15 ft. ▪ Built: 1967 ▪ Drainage Area: 3.6 sq. mi.
North Laurel Park Dam (MD Dam #377)	▪ Location: Sewall Avenue, approximately ¼ mile north of the intersection of Sewall Avenue and Baltimore Avenue in Laurel, MD (Lat: 39.115078; Long: -76.848921) ▪ Height: 29.5 ft. ▪ Built: 2000 ▪ Drainage Area: 0.31 sq. mi.
Wyndemere Dam (MD Dam #365)	▪ Location: Old Scaggsville Road, approximately ¾ mile north of the intersection of Old Scaggsville Road and MD Route 216 in Laurel, MD (Lat: 39.121616; Long: -76.858225) ▪ Height: 12 ft. ▪ Built: 1995 ▪ Drainage Area: 0.12 sq. mi.
Hobbit's Glen Golf Course (MD Dam #431)	▪ Location: Hobbit's Glen Golf Course, approximately ¼ mile north of Willow Bottom Road (Lat: 39.2273; Long: -77.9057) ▪ Height: 17 ft. ▪ Built: 1966 ▪ Drainage Area: 0.36 sq. mi.
Country Meadow (MD Dam #590)	▪ Location: North of the intersection of Country Meadow Lane and Route 1 (Lat: 39.12046; Long: -76.82824) ▪ Height: 9.4 ft. ▪ Built: 1988 ▪ Drainage Area: 0.1196 sq. mi.
Strawberry Fields (MD Dam # 564)	▪ Location: South of Briar Oak Ct, Ellicott City MD 21043. Nearest intersection Briar Oak Ct and Tangle Wood Ct (Lat: 39.219567; Long: -76.780021) ▪ Height: 18 ft. ▪ Built: 1983 ▪ Drainage Area: 0.1628 sq. mi.

Notable Dams in Howard County	
Waiting Springs (MD Dam # 578)	■ Location: Behind 6165 Waiting Spring, Columbia MD 21045. Nearest intersection Waiting Spring and Tamar Dr (Lat: 39.20227; Long: -76.82634) ■ Height: 12 ft. ■ Built: 1970 ■ Drainage Area: 0.016 sq. mi.
Jessup Park (MD Dam #468)	■ Location: Northwest of the intersection of Guilford Road and Carrol Height Avenue (Lat: 39.154028; Long: -76.775056) ■ Height: 10 ft. ■ Built: 2011 ■ Drainage Area: 0.03 sq. mi.
Laurel Lumber (MD Dam #441)	■ Location: Access if provided by CSX rail crossing at the Savage Stone Quarry. Entrance to the quarry is at the intersection of Patuxent Roange Road and US Route # 1 in Jessup MD (Lat: 39.148111; Long: -76.809944) ■ Height: 9 ft. ■ Built: 2007 ■ Drainage Area: 0.0286 sq. mi.
Linden Chapel (MD Dam #552)	■ Location: The pond is located in between 11815 Linden Chapel Rd and 11825 Linden Chapel Road, Clarksville MD (Lat: 39.226944; Long: -76.924056) ■ Height: 15.9 ft. ■ Built: 2017 ■ Drainage Area: 0.02 sq. mi.
Montgomery Run Pond # 1 (MD Dam #589)	■ Location: Pond is located north of the intersection of Montgomery Run Road and Falls Run Road along Montgomery Run Road (Lat: 39.219667; Long: -76.800639) ■ Height: 13.9 ft. ■ Built: 1987 ■ Drainage Area: 0.1133 sq. mi.
Mary Lee Dam (MD Dam #506)	■ Location: North of the intersection of Mary Lee Lane and Leishear Road (Lat: 39.145778; Long: -76.87400) ■ Height: 11 ft. ■ Built: 1985 ■ Drainage Area: 0.02 sq. mi.
Lutheran Village (MD Dam #502)	■ Location: Southwest of the intersection of Patuxent Lane and Sewall Avenue (Lat: 39.10560; Long: -76.14860) ■ Height: 13 ft. ■ Built: 2015 ■ Drainage Area: 0.04304 sq. mi.
Glenmar Pond-2 Dam (MD Dam #577)	■ Location: Northwest of the intersection of Guilford Road and Carrol Height Avenue (Lat: 39.22278; Long: -76.79957) ■ Height: 3.2 ft. ■ Built: 1984 ■ Drainage Area: 0.02 sq. mi.

Notable Dams in Howard County	
Gateway Village Community Dam (MD Dam #482)	▪ Location: Northwest of the intersection of Guilford Road and Carrol Height Avenue (Lat: 39.1523; Long: -76.8207) ▪ Height: 15.12 ft. ▪ Built: 1989 ▪ Drainage Area: 0.071 sq. mi.
Woodmark Community (MD Dam #353)	*Subject Matter Experts were consulted in order to provide the most accurate and up to date data available. At the time of the creation of the HIRA, specific data was not available for these dams.*
Whiskey Bottom West (MD Dam #598)	*Subject Matter Experts were consulted in order to provide the most accurate and up to date data available. At the time of the creation of the HIRA, specific data was not available for these dams.*
Gerwig Lane (MD Dam #579)	*Subject Matter Experts were consulted in order to provide the most accurate and up to date data available. At the time of the creation of the HIRA, specific data was not available for these dams.*
Guilford Road Dam (MD Dam #592)	*Subject Matter Experts were consulted in order to provide the most accurate and up to date data available. At the time of the creation of the HIRA, specific data was not available for these dams.*
Dobbin Road SWM Pond (MD Dam #555)	*Subject Matter Experts were consulted in order to provide the most accurate and up to date data available. At the time of the creation of the HIRA, specific data was not available for these dams.*

A Dam Failure is only expected to directly impact the homes, businesses, and transportation routes in the drainage area of Howard County's high and significant hazard dams. Areas outside of the dam drainage area are unlikely to be directly affected by the Dam Failure.

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

There have been three confirmed Dam Failure events in Howard County during the reviewed time period (1999-2019). All have been relatively minor incidents. The only notable incident has been listed below.

Notable Incidents in Howard County

June 2006 Dam Failure - A low-hazard earthen dam retaining a storm water management pond in Columbia experienced a barrel pipe collapse. The rapid release of water through the collapsed pipe resulted in the loss of a portion of the earthen embankment. Sediment from the partially failed dam flowed into the stream below the pond. The water from the pond emptied into a wooded valley and caused no damage to private property. The total cost to replace the pipe outlet and repair the damage was $264,702.70[113].

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Dam Failure in Howard County	
Historical Average (time period)	3 events (1999-2019)
Historical Annual Probability	1-20% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	0-10% chance of annual occurrence
Future Likelihood Score	1.5 (Unlikely- Infrequent)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: The future likelihood of Dam Failure in Howard County is not expected to be significantly different from the historical occurrence rate. A future annual probability of 0-10% classifies the likelihood of a Dam Failure hazard as Unlikely- Infrequent, where there is a chance of one event occurring every 99 years. An expected increase in rainfall levels and extreme storms may result in a slight increase in the likelihood of Dam Failure over time.[114] Aging dam infrastructure may also contribute to a slight increase

[113] The numbers have been adjusted to account for inflation. The cost was originally reported was $208,000 in 2006. Citation: U. S. I. C. (2019, September 12). US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

[114] National Climate Assessment. Extreme Weather. Retrieved from https://nca2014.globalchange.gov/highlights/report-findings/extreme-weather (last accessed October 10, 2019).

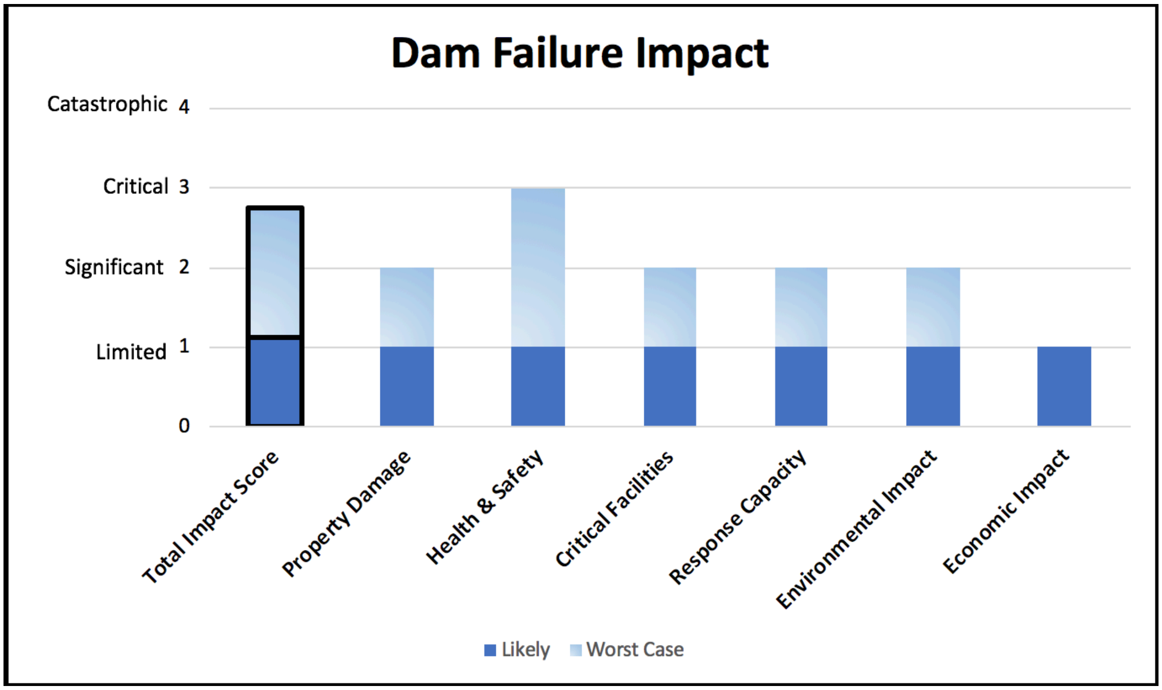
in the likelihood of Dam Failure in the future.[115] Other considerations include climate change, increase in population, and that the dams are well maintained.

[115] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Dam Failure Warning Time and Duration		
	Likely	Worst-Case
WARNING TIME	*Moderate.* Gradual release of water over several hours, accelerates with time. However, all may not come in until dam is already at point of failure.	*Short.* Release of water over 15-20 minutes, accelerates with time. However, all may not come in until dam is already at point of failure.
DURATION	*Short.* 15-20 minute rise in water which quickly drops back down within one hour.	*Very Long*. The wave of water reaches the first major roads within minutes. The wave progresses downstream for approximately eight miles over the next 60 minutes. The water levels return to pre-breach levels within one to three hours of the breach. Stabilizing the hazardous area will take several days. Full recovery will take weeks to months, depending on the severity of the failure.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Dam Failure Consequence Analysis
Likely

CATEGORY	RANKING	DESCRIPTION
PROPERTY DAMAGE	*Limited*	▪ Near 0% damage to critical and non-critical infrastructure. ▪ Minimal crop damage and river bank deterioration is likely following a minor Dam Failure hazard. Significant damage to buildings and structures is unlikely.
HEALTH AND SAFETY	*Limited*	▪ Zero deaths likely. ▪ Zero injuries likely.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Disruptions for up to 12 hours. Water or sewer lines may be washed out, but services will be recovered within hours. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Shutdown unlikely. Transportation routes will not be impacted.
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. ▪ *Fire and Rescue* – Local resources adequate. No impact on response capability or continuity of operations. ▪ *Health* – Local resources adequate. HD operations will not be affected. ▪ *Hospitals* – Local resources adequate. No strain on the hospital system. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact. Minor water pollution may occur as sediment trapped behind the dam is released and flooding erodes stream banks.
ECONOMIC IMPACT	*Limited*	▪ Limited loss in economic output. ▪ Businesses in the flood area may close for limited rehab.
TOTAL IMPACT[116]	***Limited***	▪ **Total Impact Score: 1.125 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[116] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

Dam Failure Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Significant*	▪ 5-10% damage to critical and non-critical infrastructure. ▪ High levels of structural damage to roads, buildings, and infrastructure in the flood zone. Long-term water damage, erosion, and crop damage is likely.
HEALTH AND SAFETY	*Critical*	▪ Three to four deaths likely. Deaths are likely due to physical trauma or drowning. ▪ Ten injuries likely. Injuries are likely due to physical trauma or drowning.
CRITICAL FACILITIES	*Significant*	▪ *Utilities* – Disruptions for up to 12 hours. Water or sewer lines may be washed out, but services will be recovered within hours. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Delays for several days. Flooding may wash out essential transportation infrastructure, requiring significant recovery efforts. Bridges will remain unharmed, but roadway embankments will wash out require replacement. Transportation routes may be shut down for days, and detours to accommodate repairs will cause significant delays.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Mutual aid needed. The Sherriff's Office and Maryland State Police may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state or federal assistance. There will be moderate strain on emergency services capability. ▪ *Health* – Mutual aid needed. Regular HD operations will not be affected. Health Emergency Preparedness, Communicable Diseases, and Environmental Health functions will be altered due to the emergency response. ▪ *Hospitals* – Local resources adequate. No strain on the hospital system. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Significant*	▪ Significant environmental impact. Water pollution may occur as sediment trapped behind the dam is released and flooding erodes stream banks. Some loss of wildlife and vegetation is likely during flooding. Ongoing environmental consequences may arise from trash and debris carried downstream from the dam and across the flood plain.
ECONOMIC IMPACT	*Limited*	▪ Significant in lost economic output. Other costs include cleanup and healthcare for those affected. ▪ Jobs are lost. ▪ Businesses in impacted areas close and transportation routes may be disrupted for several days.
TOTAL IMPACT[117]	***Significant-Critical***	▪ **Total Impact Score: 2.75 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

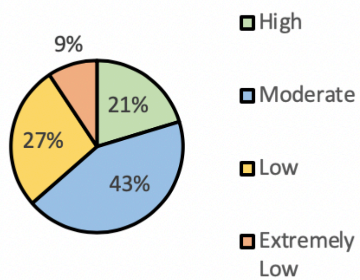
[117] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

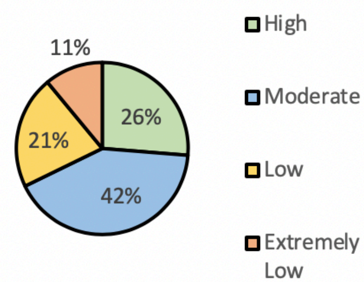
Dam Failure
Public Perception

PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD



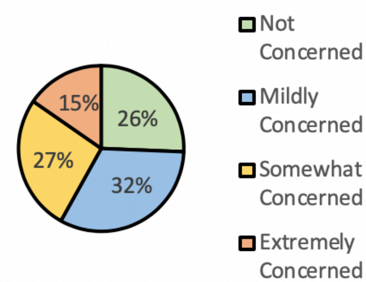
Average: 2.75
Low - Moderate

PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD



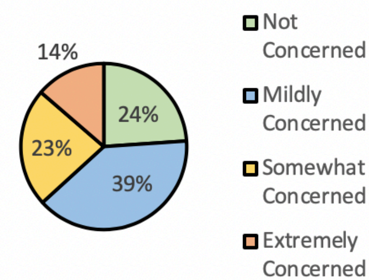
Average: 2.83
Low - Moderate

CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY



Average: 2.32
Mildly Concerned - Somewhat Concerned

CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY



Average: 2.26
Mildly Concerned - Somewhat Concerned

Emerging/Re-Emerging Infectious Diseases Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

Emerging/re-emerging infectious disease is an infectious disease that has newly appeared in a population or have existed but is rapidly increasing in incidence or geographic range in the near future. Emerging infectious diseases can be caused by previously undetected or unknown infectious agents or pathogens. The hazards can be either an outbreak, cluster, epidemic or pandemic. According to the CDC, "Epidemic refers to an increase, often sudden, in the number of cases of a disease above what is normally expected in that population in that area. Outbreak carries the same definition of epidemic but is often used for a more limited geographic area. Cluster refers to an aggregation of cases grouped in place and time that are suspected to be greater than the number expected, even though the expected number may not be known. Pandemic refers to an epidemic that has spread over several countries or continents, usually affecting a large number of people."[118]

[118] CDC. (2012). Principles of Epidemiology | Lesson 1 - Section 11. Date Accessed, June 14, 2019, from https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section11.html (last accessed October 8, 2019).

Risk Profile

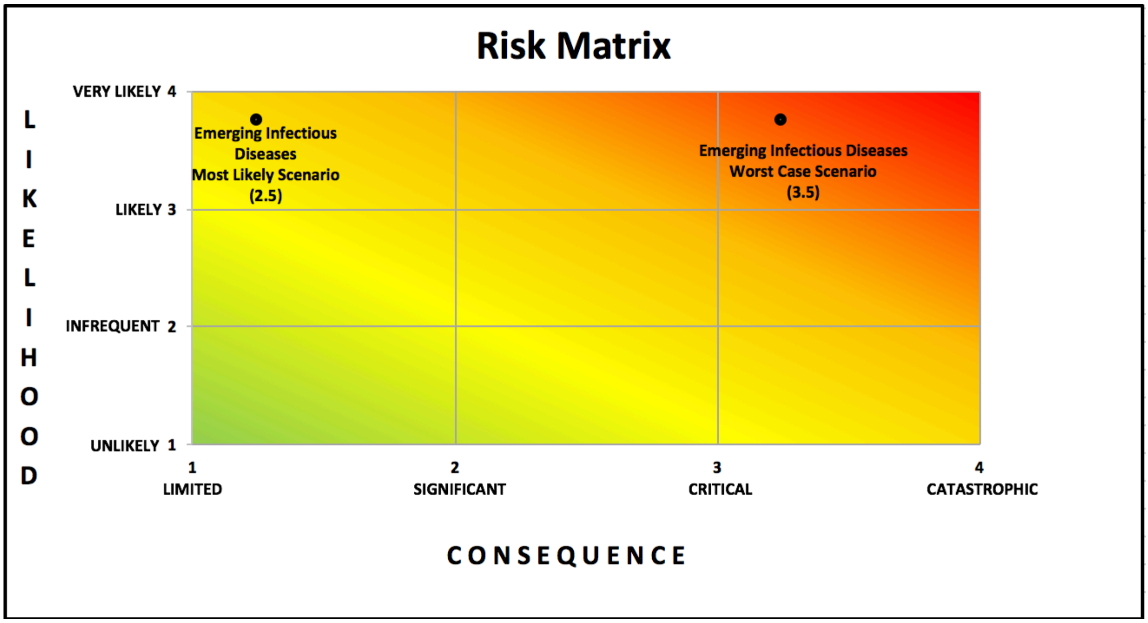
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Emerging/Re-Emerging Infectious Diseases Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	3.75 Likely-Very Likely		50%
CONSEQUENCE	**Impact**	1.25 Limited-Significant	3.25 Critical-Catastrophic	40%
	Warning Time	1 Very Long	1 Very Long	5%
	Duration	4 Very Long	4 Very Long	5%
TOTAL RISK SCORE		**2.6**	**3.4**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

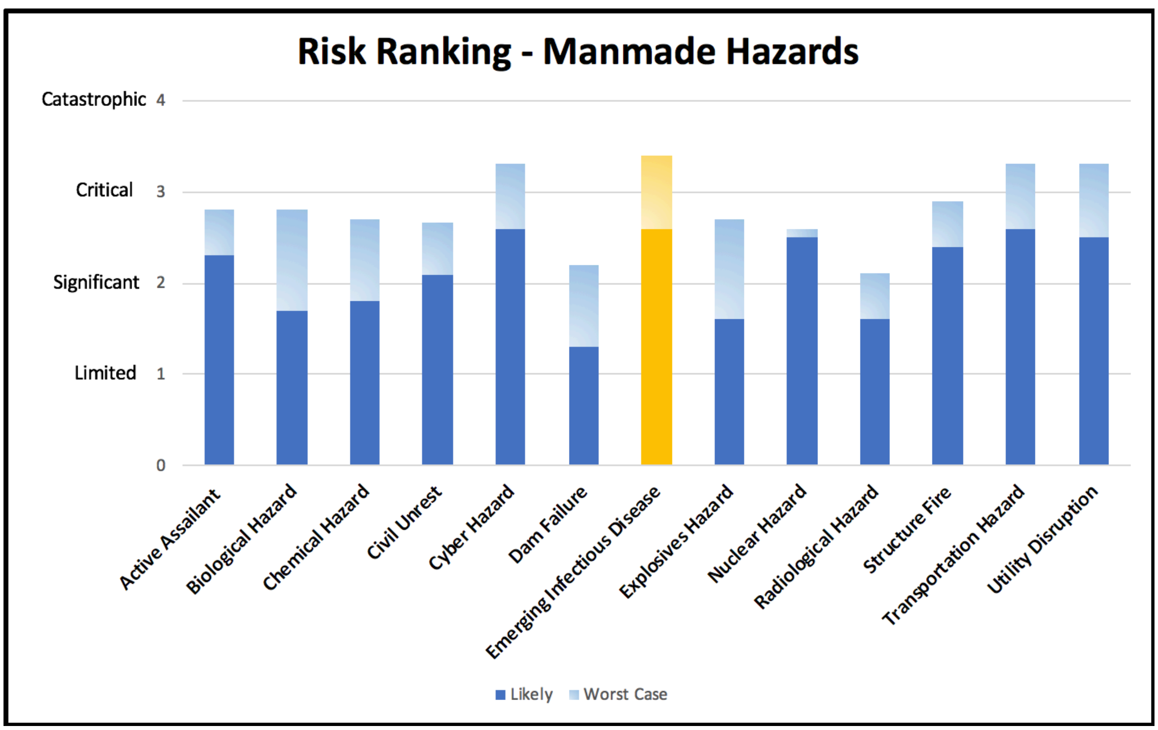
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

The World Health Organization (WHO) warned in its 2007 report that infectious diseases are emerging at a rate that has not been seen before. Since the 1970s, about 40 infectious diseases have been discovered, including Ebola, Cholera, Human Immunodeficiency Virus (HIV)/Acquired Immunodeficiency Syndrome (AIDS), Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS), Avian Flu, Swine Flu, Chikungunya, and, most recently, Zika. The CDC has reported the following morbidity statistics for data collected in the United States:

- Number of new tuberculosis cases: 9,272 (2016)
- Number of new salmonella cases: 53,850 (2016)
- Number of new Lyme disease cases: 36,429 (2016)
- Number of new meningococcal disease cases: 375 (2016)[119]

Some infectious agents or viruses, such as Influenza (Flu), can be spread person-to-person, however, it can also be passed to humans when people coexist in close proximity with agriculture-based animals such as chickens, ducks, and pigs. These animals are natural hosts of the Influenza virus and can act as mixing vessels to create different versions of Influenza that have not existed previously (e.g., H1N1, H5N1). Additional impacts can range from work disruption to school absenteeism, and hospitals may see an influx of patients.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Emerging/Re-emerging infectious diseases can affect all areas of Howard County. Densely populated areas are especially vulnerable to communicable disease outbreaks due to the increased speed and likelihood of disease transmission. Vulnerability to communicable diseases also increases with population mobility and increased exposure to individuals from diverse geographic regions. According to the D.C. Policy Center, 25% of workers in Anne Arundel and Howard Counties work in the D.C. metro area."[120] Additionally, the close proximity to major interstate highways, an international airport, and an international shipping port all increase Howard County's vulnerability to the introduction and spread of communicable diseases.[121]

[119] FastStats - Infectious Disease. Retrieved from https://www.cdc.gov/nchs/fastats/infectious-disease.htm (last accessed October 8, 2019).
[120] How many people commute between Baltimore and D.C.? Retrieved from https://www.dcpolicycenter.org/publications/how-many-people-commute-between-baltimore-and-d-c/ (last accessed September 19, 2019).
[121] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

There has been one emergency-level Emerging/Re-Emerging Infectious Disease Hazard event in Howard County during the reviewed time period (1994-2019).

Notable Incidents in Howard County

2009 H1N1 Epidemic – The H1N1 strain of the Influenza virus infected an estimated 60.8 million Americans between April 12th and 2009 to April 10th, 2010 and resulted in an estimated 274,000 hospitalizations and 12,470 deaths.[122] Howard County engaged in an emergency health response to avoid a local epidemic. In total, 40,001 local residents received the H1N1 vaccination at drive-through vaccination points, flu clinics, schools, and community centers.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of Emerging/Re-Emerging Infectious Diseases in Howard County	
Historical Average (time period)	1 event (1994-2019)
Historical Annual Probability	1-10% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	11-30% + chance of annual occurrence
Future Likelihood Score[73]	3.75 (Likely-Very Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

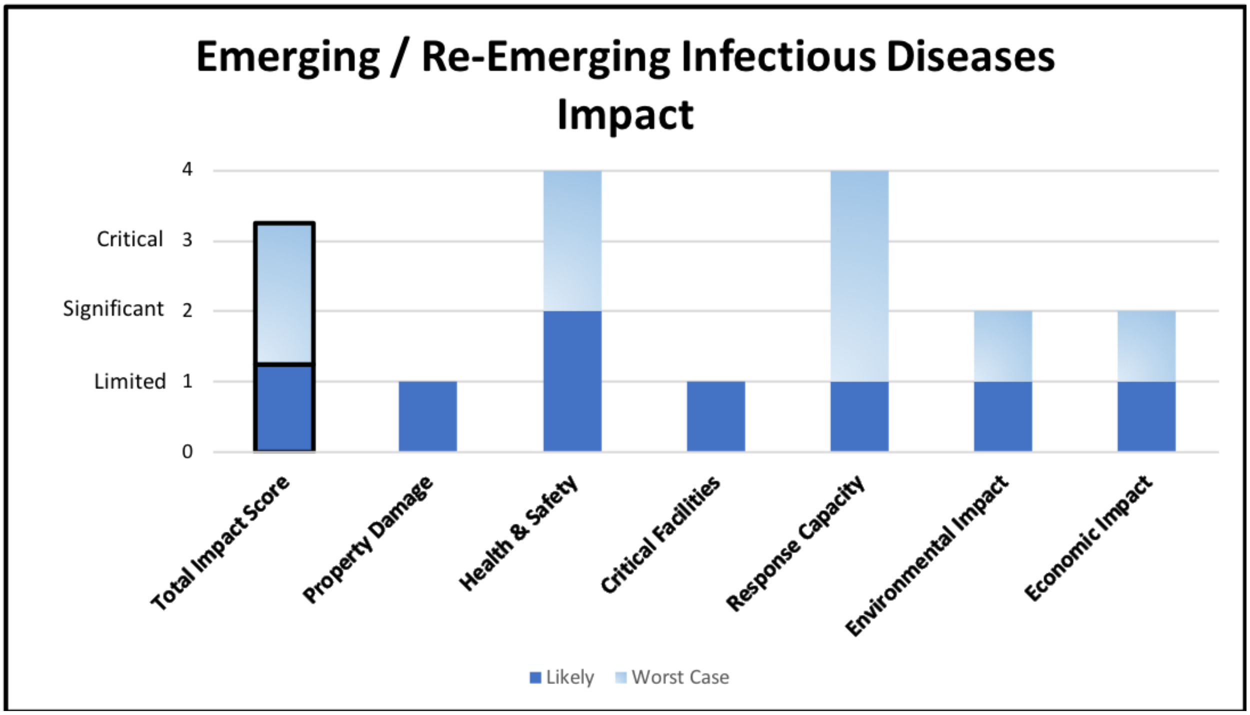
Considerations: The future likelihood of the hazard occurring is significantly higher than the historical average. The future annual probability for this hazard is 11-30% chance of annual occurrence, or, one event every 3-9 years. Some factors to consider are Howard County's increasing population and close proximity to airports. Another consideration is the existence of the current anti-vaccination movement.

[122] *H1N1 Flu – General Info,* CDC. Available at http://www.cdc.gov/h1n1flu/estimates_2009_h1n1.htm (last accessed October 8, 2019).

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Emerging/Re-Emerging Infectious Diseases Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Very Long.* The hazard will likely begin with a gradually accelerating spread of the biological agent. There may be one to two weeks of warning between the time the disease is recognized as a threat to the time that it becomes a true health emergency.	*Very Long.* The hazard will likely begin with a gradually accelerating spread of the biological agent. There may be five days to two weeks of warning between the time the disease is recognized as a threat to the time that it becomes a true health emergency.
DURATION	*Very Long.* Seasonal - Six to eight months.	*Very Long.* Six months to a year.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Emerging/Re-Emerging Infectious Diseases Consequence Analysis **Likely**				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely.		
HEALTH AND SAFETY	*Significant*	▪ There is mild work disruption and school absenteeism. ▪ Zero deaths occur. ▪ Up to 10% of population will be impacted and have an injury (flu symptoms). Injuries may include severe symptoms such as fever, coughing, vomiting, diarrhea, nausea, or shortness of breath.		
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Shutdown unlikely. Impacts to transportation will be minor and short-term.		
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local Resources Adequate. Little to no impact on response capability and continuity of operations. ▪ *Fire and Rescue* – Local Resources Adequate. Little to no impact on response capability and continuity of operations. ▪ *Health* – Communicable Disease, Community Health, and Emergency Preparedness and Response will be impacted but could likely manage local response. ▪ *Hospitals* – Local resources adequate. Hospital system would successfully manage the patient surge. ▪ *Emergency Management* – Local Resources Adequate. Little to no impact on response capability and continuity of operations.		
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited to no environmental impact.		
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. Other costs include healthcare for those affected. ▪ Zero jobs lost. ▪ Limited businesses closure may occur depending on the location of the attack. ▪ There is mild work disruption and school absenteeism.		
TOTAL IMPACT[123]	***Limited***	▪ **Total Impact Score: 1.25 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

[123] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

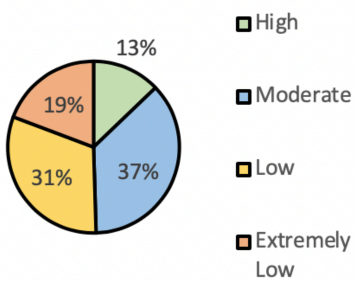
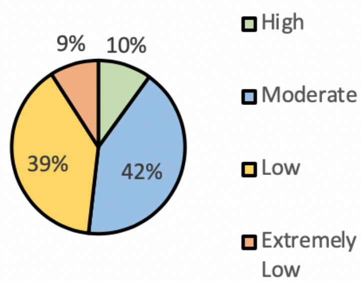
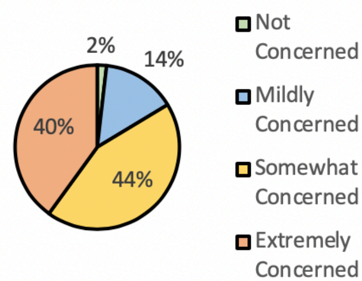
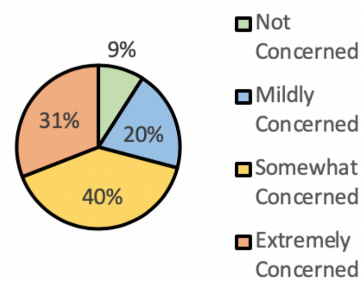
Emerging/Re-Emerging Infectious Diseases Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Damage to buildings and structures is unlikely.
HEALTH AND SAFETY	*Catastrophic*	▪ Multiple deaths likely among vulnerable populations, especially: the elderly population, young children, pregnant women, and those with multiple co-morbidities. Multiple injuries are likely as a result of contracting the illness.
CRITICAL FACILITIES	*Limited*	▪ <u>*Utilities*</u> – Shutdown unlikely. Critical mission functions will remain covered. Staff shortage will cause the delay of non-essential business functions. ▪ <u>*Information/Communications*</u> – Shutdown unlikely. If key personnel are removed from the workforce, essential behind-the-scenes functions (like data backup, etc.) will be delayed. ▪ <u>*Transportation*</u> – Shutdown unlikely. Impacts to transportation will be minor.
RESPONSE CAPACITY	*Catastrophic*	▪ <u>*Police*</u> – Local resources adequate. Sheriff's Office may be needed to support operations. ▪ <u>*Fire and Rescue*</u> – Significant and long-lasting need for state or federal assistance. EMS resources could experience significant strain. ▪ <u>*Health*</u> – Significant and long-lasting need for state or federal assistance. All HD functions will be affected to prioritize emergency response at EOC/Departmental Operations Center (DOC), points of dispensing, and call centers. Immunization will be prioritized, and most staff will be diverted to point of dispensing centers. Everyday clinic functions and health programs may be suspended. ▪ <u>*Hospitals*</u> – Moderate need for state or federal assistance. Staffing at the hospital would be extremely strained. The number of people hospitalized due to the hazard will likely occupy all hospital beds. The availability of critical care and equipment for respiratory patients will be very limited. Hospitals are overwhelmed due to the medical surge. ▪ <u>*Emergency Management*</u> – Mutual aid needed. Loss of staff may necessitate mutual aid assistance to support essential Emergency Management operations.
ENVIRONMENTAL IMPACT	*Significant*	▪ Significant to critical environmental impact. Impacts to the workforce from a disease pandemic could cause significant cascading environmental effects. Employee shortages could impact garbage disposal, wastewater treatment, maintenance of public spaces, and food safety. Potential infected sources (poultry, etc.) will be kept in quarantine or destroyed.
ECONOMIC IMPACT	*Significant*	▪ Significant economic output. Other costs include cleanup and healthcare for those affected. Business activities cease gradually at first followed by a near-complete shutdown. ▪ Massive job loss will extend for months beyond the disease pandemic. Long-term damage to Howard County image is likely.
TOTAL IMPACT[124]	***Significant-Critical***	▪ **Total Impact Score: 3.25 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[124] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Emerging / Re-Emerging Infectious Diseases Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
 *Average: 2.43* *Low - Moderate*	 *Average: 2.53* *Low - Moderate*	 *Average: 3.22* *Somewhat Concerned - Extremely Concerned*	 *Average: 2.93* *Mildly Concerned - Somewhat Concerned*

Explosives Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

An Explosives Hazard (Attack) occurs when an explosive device is intentionally used to cause harm to people, property, operational capacity, or the environment. There are also controlled explosions which are "the deliberate detonation of an explosive device under strictly controlled circumstances".[125] Controlled explosions are often work related. One example of a work-related controlled explosive is the Energetic Materials Research and Testing Center (EMRTC). EMRTC is a "major research and training division of New Mexico Tech, is internationally recognized and has over 60 years of experience in explosives research and testing."[126]

[125] Controlled explosion. Retrieved from https://www.dictionary.com/browse/controlled-explosion. (last accessed September 24, 2019).

126 Energetic Materials Research and Testing Center. Energetic Materials Research and Testing Center (EMRTC). Retrieved from http://www.emrtc.nmt.edu/ (last accessed September 24, 2019).

Risk Profile

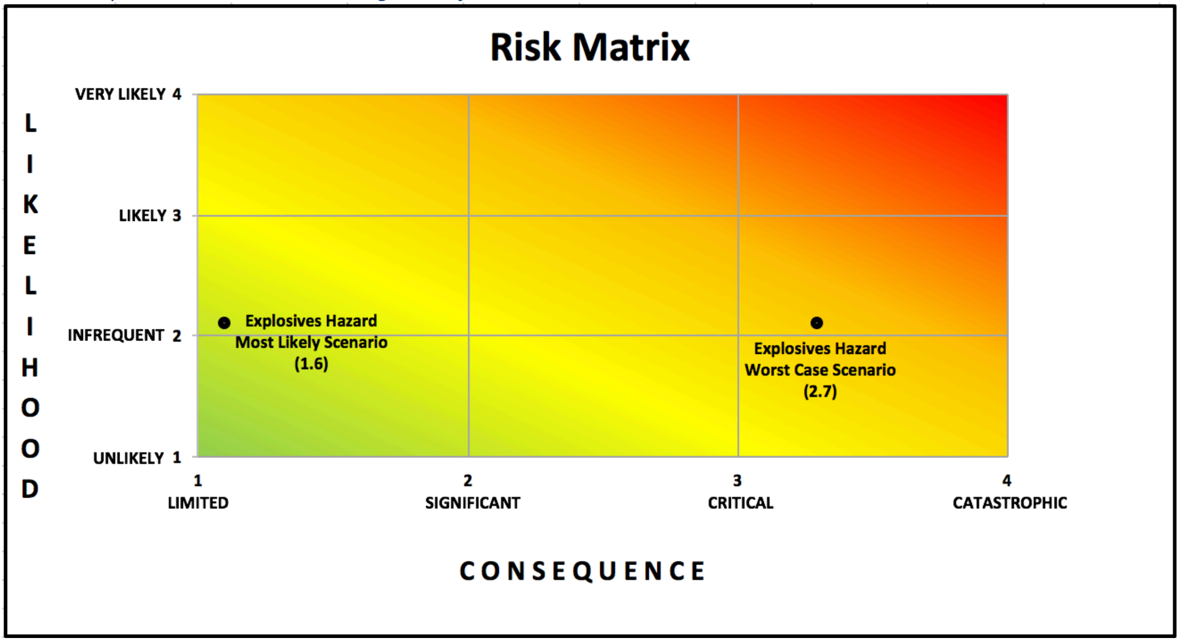
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Explosives Hazard Risk Profile					
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	2.1 Infrequent		50%
CONSEQUENCE	**Impact**	1 Limited	3.3 Critical-Catastrophic	40%
	Warning Time	2 Long	4 Short	5%
	Duration	1 Short	3 Long	5%
TOTAL RISK SCORE		**1.6**	**2.7**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

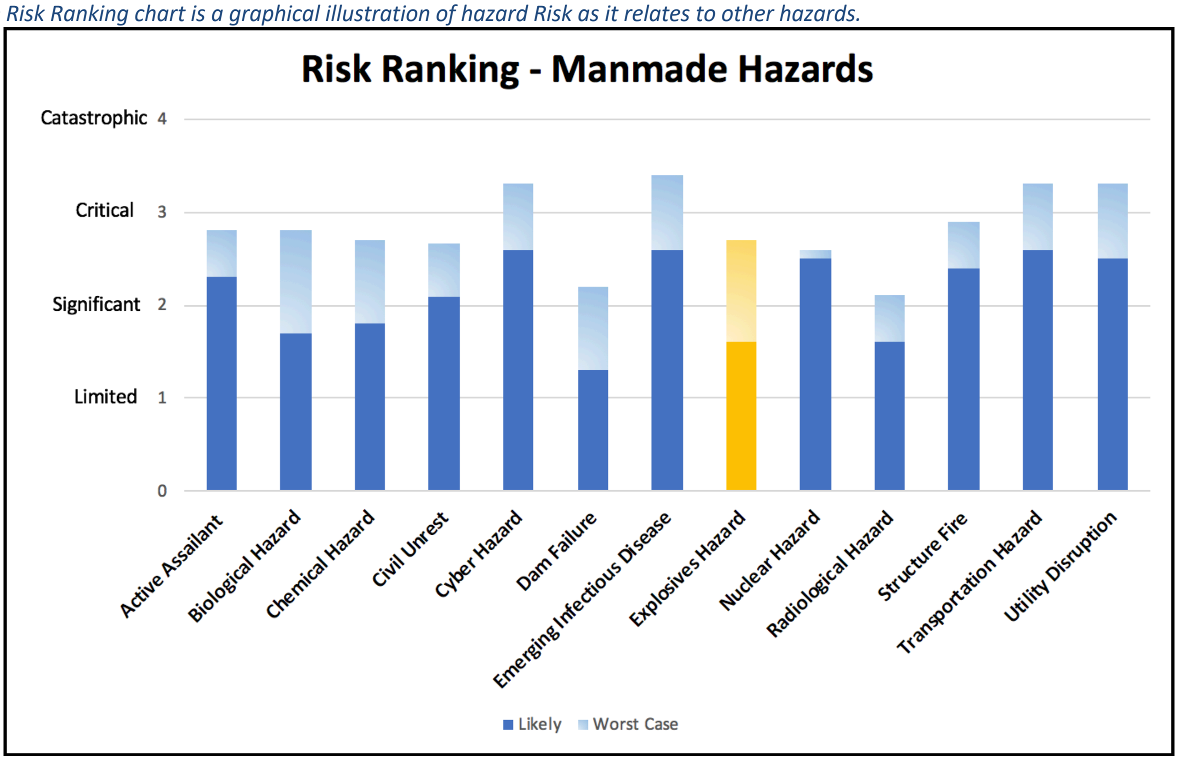
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Explosive devices can be easily transported as man-portable improvised explosive devices (IEDs), vehicle-borne IEDs, or vessel (watercraft) IEDs. Explosive devices can be easily concealed and may be detonated from a remote location.[127,128]

It is rare to have any advanced warning of an explosive attack, and the location of the attack will greatly affect the outcome. It is possible to have an IED attack take place in sparsely populated areas, but typical IED targets include densely populated locations such as office buildings, public gathering areas, special events, commercial areas, and transportation systems.

Depending on the explosive capacity, an explosive device can directly impact an area anywhere from 40 feet to one mile from the source of the explosion. Explosive capacity is measured in pounds, referring to the weight of Trinitrotoluene (TNT) needed to create an equivalent explosion. The capacity of an IED can range from 1-10lbs for a small letter bomb, pipe bomb, or small package. A vest or container can contain a bomb with an explosive capacity of up to 20lbs. Cars, Sport Utility Vehicles (SUVs), and minivans can carry bombs with 500-4,000lbs of explosive capacity. A full-sized delivery truck bomb can reach 10,000lbs of explosive capacity.[129]

The onset of an Explosives Attack Hazard is typically instantaneous. However, it can take several hours to ensure that the area of the attack is safe. Secondary hazards such as fire, utility disruption, and transportation disruption may take a day or more to resolve.

[127] For additional information see *Explosions,* FEMA. Available at http://www.ready.gov/explosions (last accessed September 24, 2019).
[128] For additional information see *Strategic National Risk Assessment,* U.S. Dept. of Homeland Security (2011). Available at http://www.dhs.gov/xlibrary/assets/rma-strategic-national-risk-assessment-ppd8.pdf (last accessed September 24, 2019).
[129] For additional information see *IED Attack: Improvised Explosive Devices,* U.S. Dept. of Homeland Security. Available at http://www.dhs.gov/xlibrary/assets/prep_ied_fact_sheet.pdf (last accessed September 24, 2019).

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

An explosives attack can occur anywhere in Howard County. Likely targets for explosives attacks in Howard County include densely populated public areas such as schools, commercial facilities, event venues, and office buildings.

The location of Howard County may increase local vulnerability to Explosives Hazards and other terrorism-related attacks. Howard County is in close proximity to valuable terrorist targets including Washington, D.C., the City of Baltimore, the Port of Baltimore, and the BWI Airport. Due to its proximity to the NCR, many Federal agencies, defense contractors, and high-profile targets maintain facilities within Howard County.[130]

[130] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

Howard County is home to two licensed blasting operations that involve earth mining. Several times throughout the year additional blasting is done throughout the County at various construction sites. There were eight responses to confirmed Explosive Hazard threats in Howard County between 2010 and 2014, although all were disarmed prior to detonation. Between 1996 and 2014, County response agencies have responded to 47 calls for removal of explosive devices.[131] From 2000-2019, there was an estimated total of 20[132] incidents that were considered Explosive Hazard events.

Notable Incidents in Howard County

All recent Explosives Hazard events in Howard County have been considered minor incidents. Local events typically involve experimentation with homemade chemical bombs. During the 2014 active shooter attack at the Columbia Mall, the assailant was armed with several small homemade explosives. The explosives were never detonated.

In 2014, there were five Explosive Hazard events and only one caused damage to a private dwelling. The estimated total in damages was $5,418.65.[133][134]

In 2015, there were five Explosive Hazard events none of which resulted in deaths or injuries.[135]

In 2016, there was one Explosive Hazard event that did not result in any injuries or loss of life.[136]

In 2017, there were no Explosive Hazard events.[137]

In 2018, there was one Explosive Hazard event in Columbia that did not result in any injuries or loss of life.[138]

[131] *Howard County CAD Report 1/01/1996 – 12/31/2013 (unpublished)*, Howard County DFRS (2014).
[132] This number was calculated by totaling the 8 responses to explosive threats from 2010-2014 and the 12 explosive hazard events recorded between 2014 and 2019.
[133] The damage amount was originally reported as $5,000 in 2014. The number shown above is altered to account for inflation. Citation: US Inflation Staff. (2019, September 12). US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[134] Howard County Fire Department and Rescue Services, 2019.
[135] Howard County Fire Department and Rescue Services, 2019.
[136] Howard County Fire Department and Rescue Services, 2019.
[137] Howard County Fire Department and Rescue Services, 2019.
[138] Howard County Fire Department and Rescue Services, 2019.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

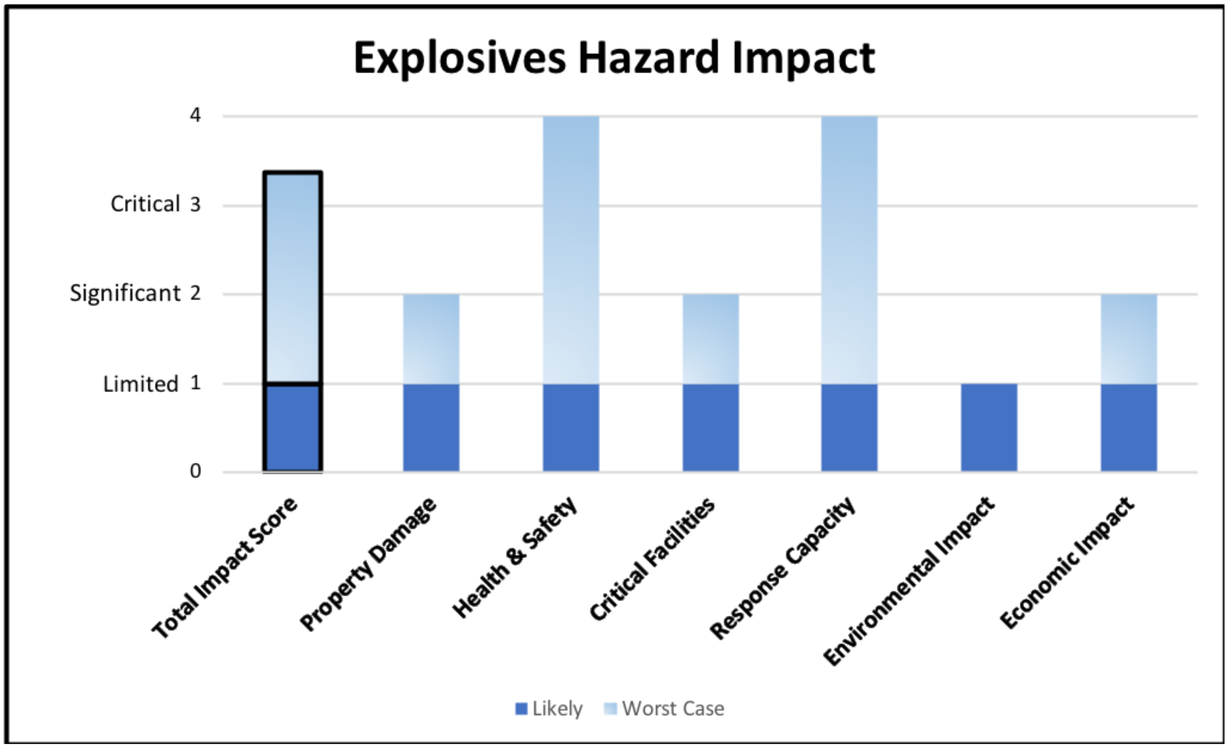
Future Likelihood of an Explosives Hazard in Howard County	
Historical Average (time period)	20 recorded events (2000-2019)
Historical Annual Probability	1-10% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	1-10% chance of annual occurrence
Future Likelihood Score	2.1 (Infrequent)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: The future annual probability of this event occurring is 1-10% chance of annual occurrence, or one event every 10-99 years. Howard County has not experienced a successful Explosives Attack in recent history. The increased threat of terrorism and the County's proximity to high value terrorist targets may contribute to an increase in the likelihood of an explosives attack in the future. A final factor contributing to the increased likelihood is access to information. The rapidly increasing online availability of bomb-making information and access to extremist ideologies contributes greatly to the increased future likelihood of an explosives attack in Howard County.[130] However, it is important to note that routine, planned, and controlled explosions at quarries, for example, do occur regularly.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Explosives Hazard Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Long.* Planned event, significant warning time.	*Short.* No warning time prior to an attack.
DURATION	*Short.* Hazard onset is nearly instantaneous.	*Long.* Hazard onset is nearly instantaneous. It may take six to 36 hours to declare the hazard location safe.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Explosives Hazard Consequence Analysis Likely		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ Near 0% damage to critical and non-critical infrastructure. ▪ Damage limited to specific quarry site planned explosion.
HEALTH AND SAFETY	*Limited*	▪ Zero deaths likely. ▪ Zero injuries likely.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Delays for less than twelve (12) hours. Impacts to transportation will be minor and short-term. Road closures will be localized, and delays will not be excessive.
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. ▪ *Fire and Rescue* – Local resources adequate. ▪ *Health* – Local resources adequate. HD operations will not be affected. ▪ *Hospitals* – Local resources adequate. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited to no environmental impact. Less than a day of clean-up. Impact to a localized area.
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. ▪ Zero jobs lost. ▪ Limited business disruption in the immediate hazard area- People who live around the site will be concerned.
TOTAL IMPACT[139]	***Limited***	▪ **Total Impact Score: 1 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[139] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

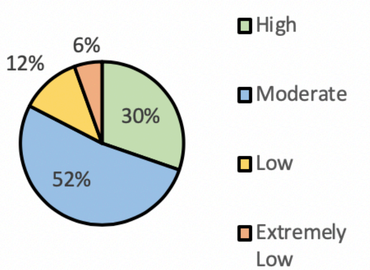
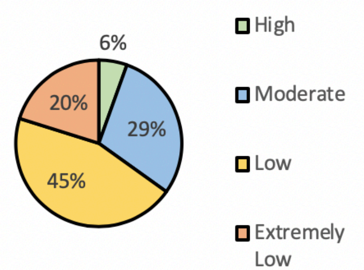
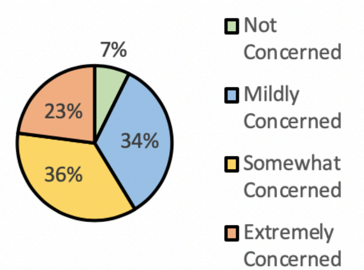
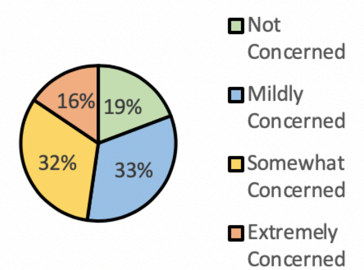
Explosives Hazard Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Significant*	▪ Significant damage to critical and non-critical infrastructure. ▪ A large explosive device will likely cause significant structural damage and building collapse in the immediate area. The attack may cause superficial damage to property and structures within several blocks of the attack site.
HEALTH AND SAFETY	*Catastrophic*	▪ 100 deaths likely. 100-300 injuries likely. Deaths and injuries are likely the result of physical trauma resulting from the explosive blast and the subsequent structural collapse.
CRITICAL FACILITIES	*Significant*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Delays for three to five days. Initial transportation delays will be caused by people exiting the hazard area. Major closures will occur in the immediate aftermath of the attack, and localized transportation routes will be closed for several days.
RESPONSE CAPACITY	*Catastrophic*	▪ *Police* – Significant and long-lasting need for Federal assistance. Moderate strain to response capacity and depleted road strength. Terrorism response automatically triggers federal law enforcement involvement. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Significant and long-lasting need for federal assistance. There will likely be long-lasting impact to fire/rescue hazardous materials response capabilities. Regional EMS resources will be overwhelmed. Significant mutual aid assistance will likely be required to maintain regular calls for service. ▪ *Health* – Mutual aid needed. Regular HD operations will not be affected, but Health Emergency Preparedness may be necessary to support the emergency response. ▪ *Hospitals* – Mutual aid needed. The hospital Emergency Department will likely be entirely full due to the patient surge. All minor injuries and illnesses will be diverted to other hospitals. Emergency walk-ins will continue to receive treatment, but there will be extensive delays. ▪ *Emergency Management* – Mutual aid needed. Emergency Management may need assistance to coordinate planning resources, investigation activities, and shelter operations. Long shifts may necessitate additional Emergency Management staff support or incident management staff to sustain extended response and recovery activities.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited to no environmental impact. Impact to a localized area.
ECONOMIC IMPACT	*Significant*	▪ Significant amount lost economic output. Other costs include cleanup and healthcare for those affected. ▪ Business closures and job disruption are likely in the impacted area. Howard County image is likely to suffer.
TOTAL IMPACT[140]	***Critical - Catastrophic***	▪ **Total Impact Score: 3.375 on a scale of 1 (Limited) to 4 (Catastrophic).**

[140] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Limited	*Significant*	*Critical*	*Catastrophic*

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Explosives Hazard **Public Perception**			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
			
Average: 3.07 *Moderate - High*	*Average: 2.20* *Low - Moderate*	*Average: 2.74* *Mildly Concerned - Somewhat Concerned*	*Average: 2.44* *Mildly Concerned - Somewhat Concerned*

Nuclear Blast Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

A Nuclear Blast Hazard is the result of a device that uses a nuclear reaction to create an explosion far more powerful than that of conventional explosives.[141] When nuclear weapons or improvised nuclear devices (INDs) explode, they give off energy in the form of a blast wave, intense light, heat, and radiation.

Risk Profile

The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

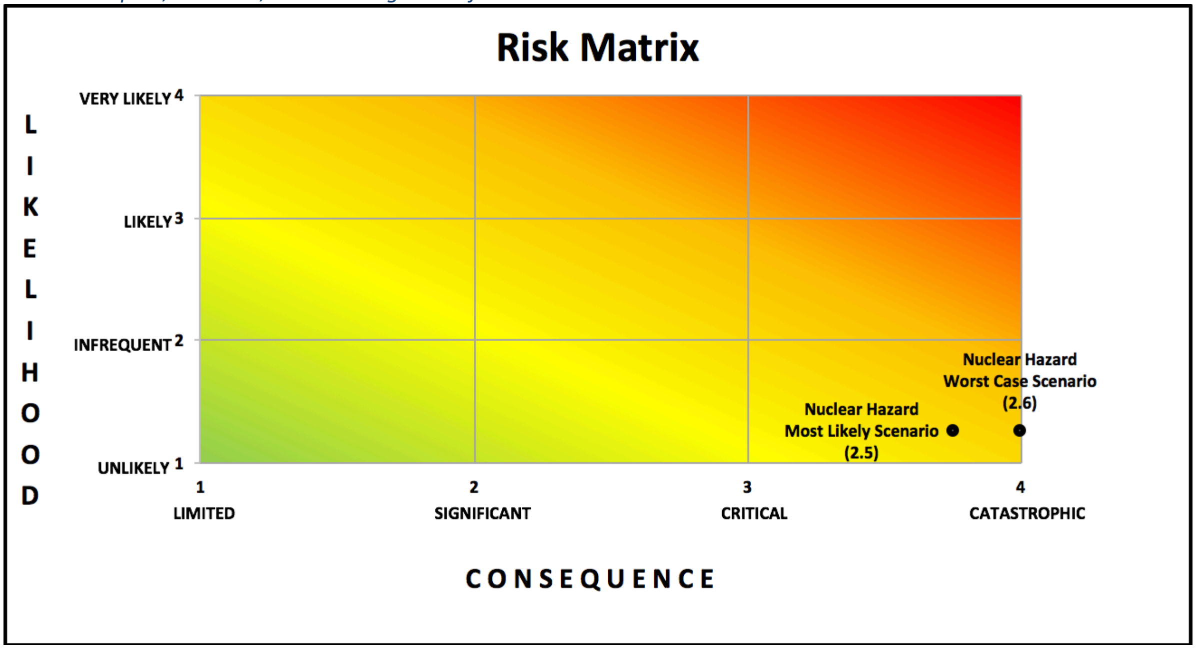
Nuclear Blast Hazard Risk Profile				
	Risk Assessment Category	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
LIKELIHOOD	**Likelihood**	1.25 Unlikely-Infrequent		50%
CONSEQUENCE	**Impact**	3.7 Critical-Catastrophic	4 Catastrophic	40%
	Warning Time	4 Short	4 Short	5%
	Duration	4 Very Long	4 Very Long	5%
	TOTAL RISK SCORE	**2.5**	**2.6**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

[141] *More Information on Types of Radiation Emergencies,* CDC. Available at https://www.cdc.gov/nceh/radiation/emergencies/moretypes.htm (last accessed October 4, 2019).

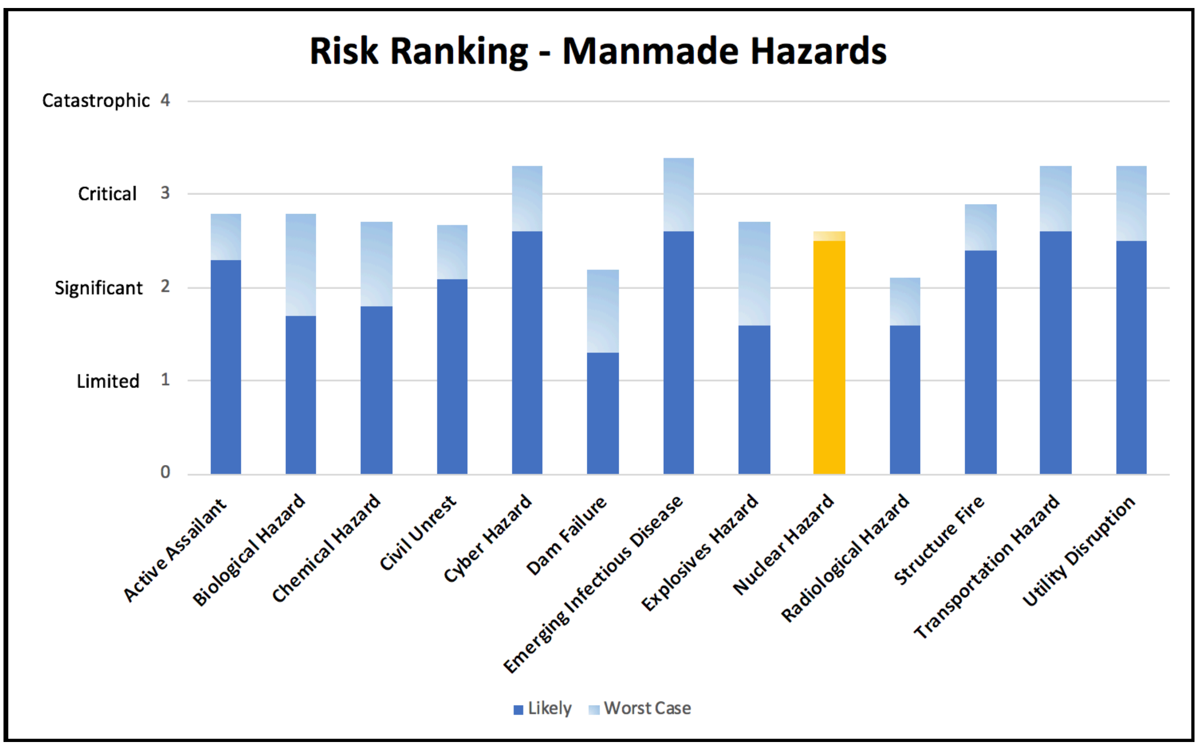
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

A Nuclear Blast is hazardous in many distinct ways. A Nuclear Blast results in a large fireball that vaporizes everything within the immediate blast area and carries it upward. Light and heat radiate outward from the explosion, and an electromagnetic pulse is emitted during the first few seconds of the blast. A blast wave generates overpressure and propagates rapidly out from the epicenter. Prompt radiation levels are high near the epicenter during the first minute of the explosion but decrease rapidly with time and distance. As the debris cloud cools, dust-like particles of radioactive material are dispersed by the wind and drop back to earth as fallout.[142]

It is rare to have any advanced warning of a Nuclear Blast that is detonated at ground level. Although there are systems in place to detect the launch of nuclear missiles, the advanced warning time may be measured in minutes rather than hours.

Explosive capacity for nuclear weapons is measured in kilotons (kt) (1kt = 1,000 tons) or megatons (Mt) (1Mt = 1,000,000 tons). This unit of measurement refers to the weight of TNT that would be required to release an equivalent level of explosive energy. The energy yield of a Nuclear Blast can vary greatly. The lightest tactical nuclear weapons have a yield of 0.01kt. Bombs like those dropped in World War II have a yield of 13-20kt. Modern nuclear weapons like those used by the U.S. and Russian militaries can have explosive yields of 40-50Mt.

The area affected by a Nuclear Blast will vary depending on the explosive yield of the bomb. A 0.1kt explosion will have a Severe Damage Zone of 200 yards, a Moderate Damage zone extending to ¼ mile, and a Light Damage Zone extending to one mile from the epicenter of the explosion. A 1kt explosion will have a Severe Damage Zone of ¼ mile, a Moderate Damage zone extending to ½ mile, and a Light Damage Zone extending to two miles from the epicenter of the explosion. An explosion greater than 10kt will have a Severe Damage Zone of at least ½ mile radius, a Moderate Damage zone extending to one-mile radius, and a Light Damage Zone extending to a three-mile radius from the epicenter of the explosion.[142] The electromagnetic pulse (EMP) emitted by a Nuclear Blast can easily span hundreds of miles.

Depending on the wind and weather conditions at the site of the attack, radioactive fallout can occur many miles from the blast. The highest concentrations of radiation fall closest to the detonation site, while exposure outside of the blast radius is greatly affected by weather. Radiation dose from fallout is largely dependent on time, distance, and shielding.

[142] *Nuclear Detonation: Weapons, Improvised Nuclear Devices,* U.S. Dept. of Health and Human Services. Available at http://www.remm.nlm.gov/nuclearexplosion.htm (last accessed October 4, 2019).

The size of a Nuclear Blast makes it unlikely that a nuclear weapon attack could occur without directly impacting a significant percentage of the population in the region of the attack. In the case of a military or terrorist attack, the Nuclear Blast will likely be targeted at an urban area for maximum impact.

The onset of a Nuclear Blast is immediate, but effects of the blast can cause the affected area to remain hazardous for many years. Blast effects, thermal effects, and the electromagnetic pulse following a nuclear explosion are nearly instantaneous. Radioactive fallout decays rapidly in the hours following a nuclear detonation. After three hours, initial radiation exposure rates are down to 20%, exposure rates are down to 10% after 8 hours, and exposure rates fall to 1% after 48 hours. Radioactive contamination in the blast area is highly dependent on the type and yield of the nuclear explosive device. A large Nuclear Blast can result in radioactive contamination that remains hazardous for up to 10 years.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

The entire planning area is susceptible to the effects of a Nuclear Blast. Given the large geographic scope of a Nuclear Blast, an attack many miles away in Washington, D.C. or the City of Baltimore may create a catastrophic hazard within Howard County.

The location of Howard County may increase local vulnerability to a Nuclear Blast hazard and other terrorism-related attacks. Howard County is in close proximity to valuable military and terrorist targets including Washington, D.C., the City of Baltimore, the Port of Baltimore, and BWI Airport. Due to its proximity to the NCR, many Federal agencies, defense contractors, and high-profile targets maintain facilities within Howard County.[143]

[143] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

There has never been a Nuclear Blast Hazard in Howard County (1945-2019). Howard County is centrally located between Washington, D.C. and Baltimore, Maryland. A nuclear blast at either of these high volubility targets would be felt in Howard County.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

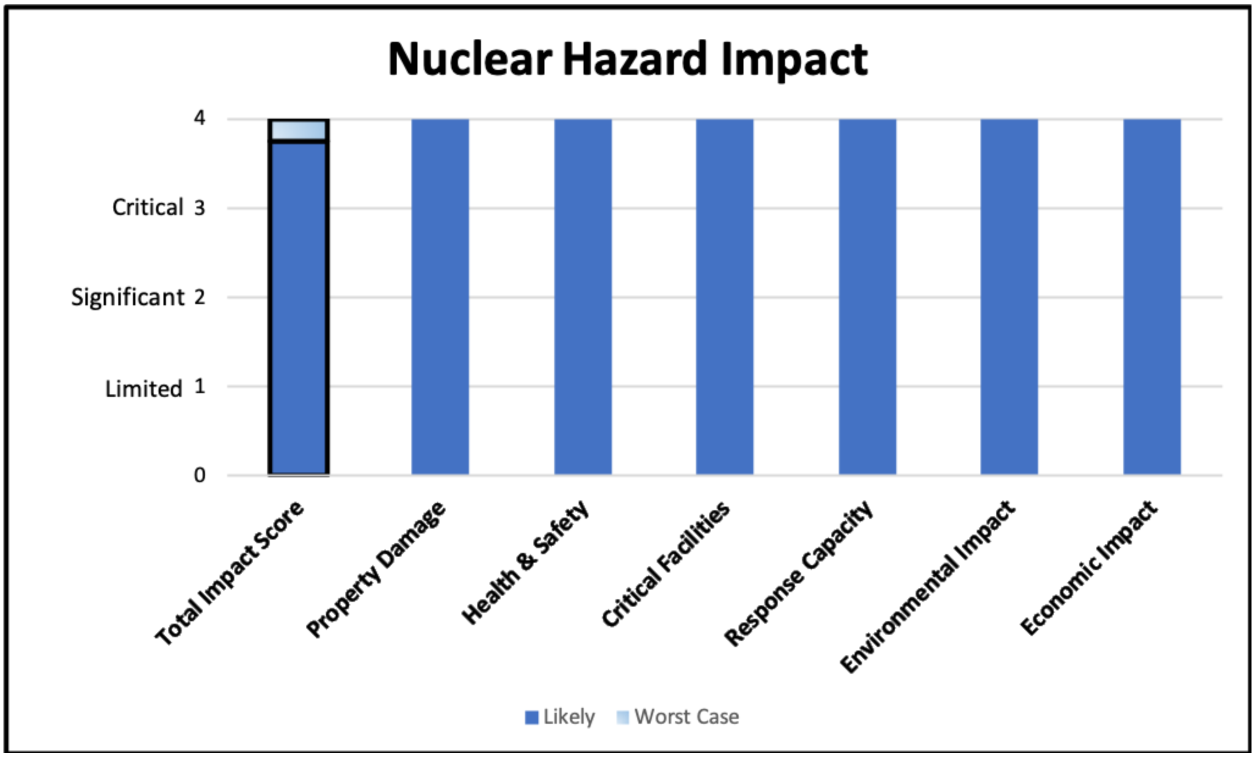
Future Likelihood of a Nuclear Blast Hazard in Howard County	
Historical Average (time period)	0 recorded events (1945-2019)
Historical Annual Probability	0% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	0-1% chance of annual occurrence
Future Likelihood Score	1.2 (Unlikely-Infrequent)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: The future likelihood of a Nuclear Blast Hazard in Howard County is not expected to be significantly different from the historical occurrence rate. A future annual probability of 0-1% classifies the likelihood of a Nuclear Blast hazard as Unlikely, or, one event every 100 years. Increases in geopolitical tensions and the proliferation of nuclear technology may result in a slight increase in likelihood over time.[143] Other considerations include Howard County's proximity to Washington, D.C., the National Security Agency (NSA), the City of Baltimore, Peach Bottom Atomic Power Station (PBAPS) and Calvert Cliffs Nuclear Power Plant (CCNPP).

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Nuclear Blast Hazard Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time likely prior to an attack. In some cases, there may be a short warning time of up to one hour.	*Short.* No warning time prior to an attack.
DURATION	*Very Long.* In the event of a Nuclear Blast in a neighboring region, onset of the EMP hazard is nearly instantaneous. Radioactive fallout occurs over a period of one week, and it takes months before the radioactive hazard is neutralized in Howard County. The economic impact could last decades.	*Very Long.* In the event of a Nuclear Blast in Howard County, onset of the hazard is nearly instantaneous. Radiation will likely persist at a hazardous level for many years. It may take up to ten years to declare the hazard location safe.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Nuclear Blast Hazard Consequence Analysis Likely		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Catastrophic*	▪ Major damage to critical and non-critical infrastructure. The EMP from a nuclear blast in a neighboring jurisdiction would cause significant disruption to electronics equipment in Howard County.
HEALTH AND SAFETY	*Catastrophic*	▪ Many deaths and injuries are likely, although the exact number is difficult to predict. ▪ In the case of a nuclear blast in a neighboring jurisdiction, deaths and injuries in Howard County would likely be due to cascading effects rather than direct effects of the attack itself. Radiation sickness may result from radioactive fallout.
CRITICAL FACILITIES	*Catastrophic*	▪ *Utilities* – Shut down for days or weeks. If employees are not able to work, drinking water and waste water systems will shut down within one day. ▪ *Information/Communications* – Shut down for days or weeks. The EMP will cause significant damage to all electronically based systems, including phone service and internet access. ▪ *Transportation* – Extensive delays for weeks or months. Evacuation will cause severe traffic delays on nearly all transportation routes. Transportation staff will be unavailable for work for an extended period of time.
RESPONSE CAPACITY	*Catastrophic*	▪ *Police* – Mutual aid needed. Terrorism response automatically triggers federal law enforcement involvement. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Significant and long-lasting need for state or federal assistance. Response capability would be severely strained even if a nuclear blast were to occur in a neighboring jurisdiction. Maintaining continuity of operations would be difficult. ▪ *Health* – Significant and long-lasting need for state or Federal assistance. Nearly all HD operations will be severely affected due to shelter in place recommendations, evacuation of staff, and emergency response. ▪ *Hospitals* – Significant and long-lasting need for state or Federal assistance. Significant strain on hospital capacity. The hospital will likely be completely full for up to one month with large number of psychological casualties (worried well) for months. ▪ *Emergency Management* – Significant and long-lasting need for state or Federal assistance. Considerable ongoing assistance may be necessary to support Emergency Management in sheltering activities, evacuation planning, response coordination, and recovery planning. Loss of staff may necessitate significant assistance to support EOC operations and Multi-agency coordination.
ENVIRONMENTAL IMPACT	*Catastrophic*	▪ Critical to Catastrophic environmental impact. Long term pollution and contamination. Loss of species. Renewable, but only after some time. Radioactive material would contaminate the air, water, and land for months. Radiological materials that can kill or debilitate humans may also kill or debilitate other animal life in the area. The contamination will include surface drinking water.
ECONOMIC IMPACT	*Catastrophic*	▪ Billions in lost economic output. Other costs include cleanup and healthcare for those affected. ▪ Business ceases. Job loss and recovery incalculable.
TOTAL IMPACT[144]	***Critical - Catastrophic***	▪ **Total Impact Score: 3.75 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[144] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

Nuclear Blast Hazard Consequence Analysis
Worst-Case

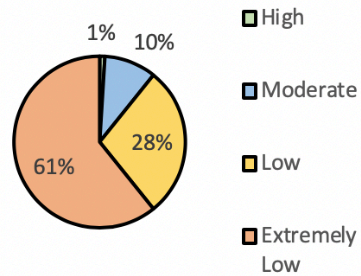
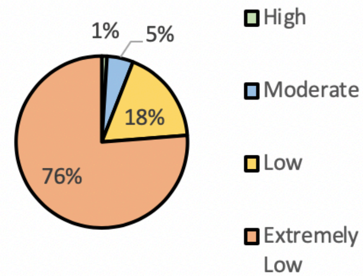
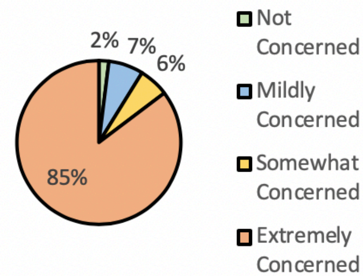
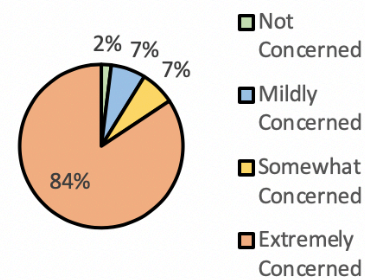
CATEGORY	RANKING	DESCRIPTION
PROPERTY DAMAGE	*Catastrophic*	▪ 100% damage to critical and non-critical infrastructure. Damage would come from many sources, including the nuclear fireball, blast overpressure, EMP, and prompt and delayed radiation.
HEALTH AND SAFETY	*Catastrophic*	▪ 10,000-20,000 deaths likely and 100,000+ injuries likely. Deaths and injuries will likely be the result of complete vaporization, radiation sickness, overpressure blast injuries, or trauma from structural collapse. Multiple deaths and injuries will also occur from any number of cascading effects from the overpressure blast, radioactive fallout, EMP, and mass evacuation.
CRITICAL FACILITIES	*Catastrophic*	▪ *Utilities* – Shut down for 10+ years. Total shutdown of all system will occur. Restoring service will require a complete rebuild of utilities infrastructure. ▪ *Information/Communications* – Shut down for 10+ years. Restoring service will require a complete rebuild of information and communications infrastructure. ▪ *Transportation* – Shut down for 10+ years. A large percentage of transportation infrastructure will be destroyed by the blast. Remaining routes will be shut down by mass evacuations. Damages will take more than a decade to rebuild.
RESPONSE CAPACITY	*Catastrophic*	▪ *Police* – Significant and long-lasting need for state or Federal assistance. Local law-enforcement capabilities would be non-existent. ▪ *Fire and Rescue* – Significant and long-lasting need for state or Federal assistance. There would be no local response capability or continuity of operations. ▪ *Health* – Significant and long-lasting need for state or Federal assistance. HD operations will be completely disrupted. ▪ *Hospitals* – Significant and long-lasting need for state or Federal assistance. All hospital services and facility would be unavailable. ▪ *Emergency Management* – Significant and long-lasting need for state or Federal assistance. Local Emergency Management would be rendered completely ineffective. Surviving staff would likely evacuate with the rest of the population, and all local Emergency Management functions would be off-line.
ENVIRONMENTAL IMPACT	*Catastrophic*	▪ Catastrophic environmental impact. Species extinction is expected, generational birth defects are likely among surviving animal life, and the area will not be livable or renewable. The radioactive blast would damage or destroy plant and animal life within the impact zone. The radioactive material would contaminate the air, water, and land for 10 years or more. The contamination will include surface drinking water supply sources for the region and County. Agricultural land will not be usable for cropland or animal pasture. Failed sewage systems due to failed pumps or computer technology may cause contamination or sewage issues.
ECONOMIC IMPACT	*Catastrophic*	▪ $200 billion in lost economic output. Other costs include cleanup and healthcare for those affected. Significant amount of jobs lost. All County and Regional economic activity is gone for at least 10 years.
TOTAL IMPACT[145]	***Catastrophic***	▪ **Total Impact Score: 4.00 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[145] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Nuclear Blast Hazard Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
			
Average: 1.51 *Extremely Low - Low*	*Average: 1.31* *Extremely Low - Low*	*Average: 3.75* *Somewhat Concerned - Extremely Concerned*	*Average: 3.74* *Somewhat Concerned - Extremely Concerned*

Radiological Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

It is important to note that in the 2015 HIRA, Radiological Hazards were reviewed separately as "Radiological Attacks" and "Unintentional Radiological Substance Release". In the updated 2019 HIRA, Radiological Hazards have been expanded to include all Radiological Hazards, both intentional and unintentional. An Intentional Radiological Hazard (Attack) occurs when a population is intentionally exposed to radiation through a non-nuclear mechanism (nuclear weapon hazards are profiled separately under "Nuclear Hazards"). A Radiological Attack may take the form of a radiological exposure device (RED) or a radiological dispersal device (RDD) (also known as a dirty bomb).[146]

Radiological exposure devices may be concealed in public places, and people who pass close to the RED may be exposed to radiation. A RDD, or dirty bomb, is a mix of traditional explosives and radioactive powder or pellets. A dirty bomb is incapable of creating an atomic blast and should not be confused with an improvised nuclear device. A dirty bomb blast carries radioactive material into the surrounding area, but the main danger typically comes from the explosion, not the radiation.[147] REDs and RDDs are not capable of creating an atomic blast.

An Unintentional Radiological Substance Release Hazard occurs when radiation is accidentally discharged into the environment. Unintentional Radiological Substance Release Hazard may occur as the result of a nuclear power plant accident, a transportation accident, or a workplace incident.[148] An accident at a nuclear power plant could release a plume of dangerous radiation over an area. Radioactive materials in the plume zone can settle and contaminate buildings as well as people, food, water, and livestock who are outdoors. Radioactive material is also commonly transported by trucks and rail, but transportation

[146] *More Information on Types of Radiation Emergencies,* CDC. Available at https://www.cdc.gov/nceh/radiation/emergencies/moretypes.htm (last accessed September 27, 2019).
[147] For additional information see *Radiological Attack: Dirty Bombs and Other Devices,* U.S. Dept. of Homeland Security (2004). Available at http://www.dhs.gov/xlibrary/assets/prep_radiological_fact_sheet.pdf (last accessed September 27, 2019).
[148] *More Information on Types of Radiation Emergencies,* CDC. Available at https://www.cdc.gov/nceh/radiation/emergencies/moretypes.htm (last accessed September 27, 2019).

accidents involving radioactive material rarely result in significant exposure to radiation. Workplace radiation incidents may occur in health care facilities, research institutions, and industrial operations if radiation sources are not stored correctly, safety controls malfunction, or safety procedures are not followed.

Risk Profile

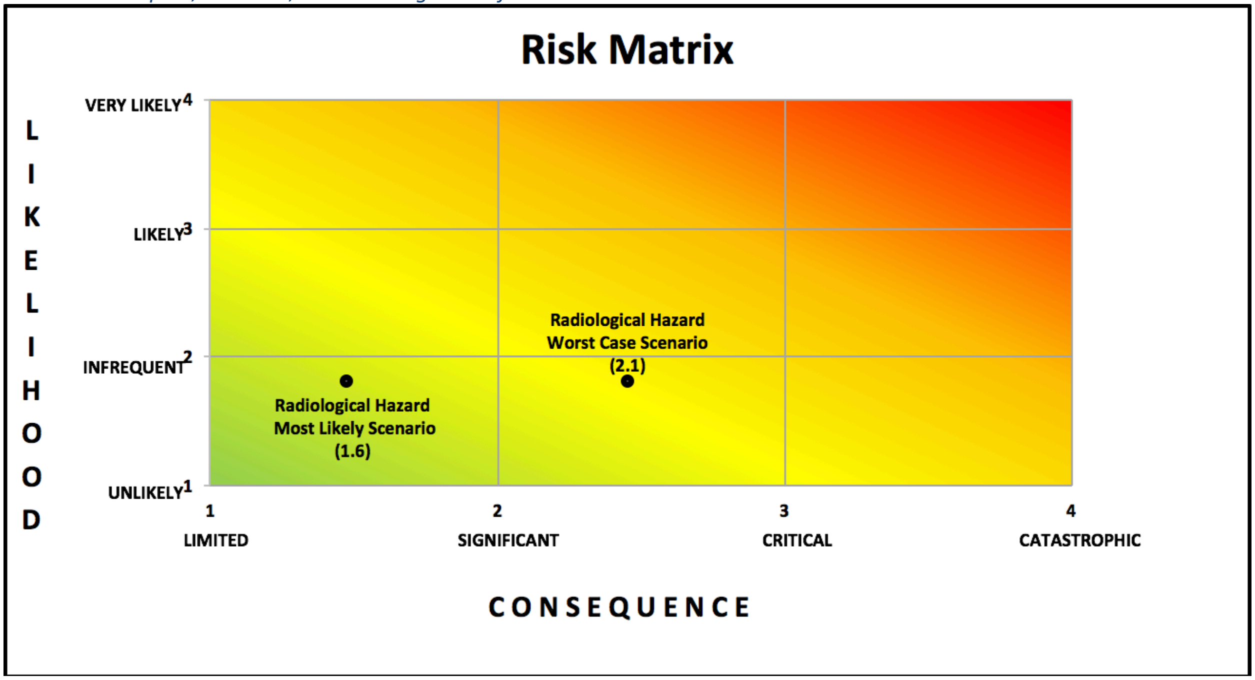
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Radiological Hazard Risk Profile				
	Risk Assessment Category	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
LIKELIHOOD	**Likelihood**	1.8 Unlikely-Infrequent		50%
CONSEQUENCE	**Impact**	1.1 Limited	2.25 Significant-Critical	40%
	Warning Time	4 Short	4 Short	5%
	Duration	2 Moderate	3 Long	5%
TOTAL RISK SCORE		**1.6**	**2.1**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

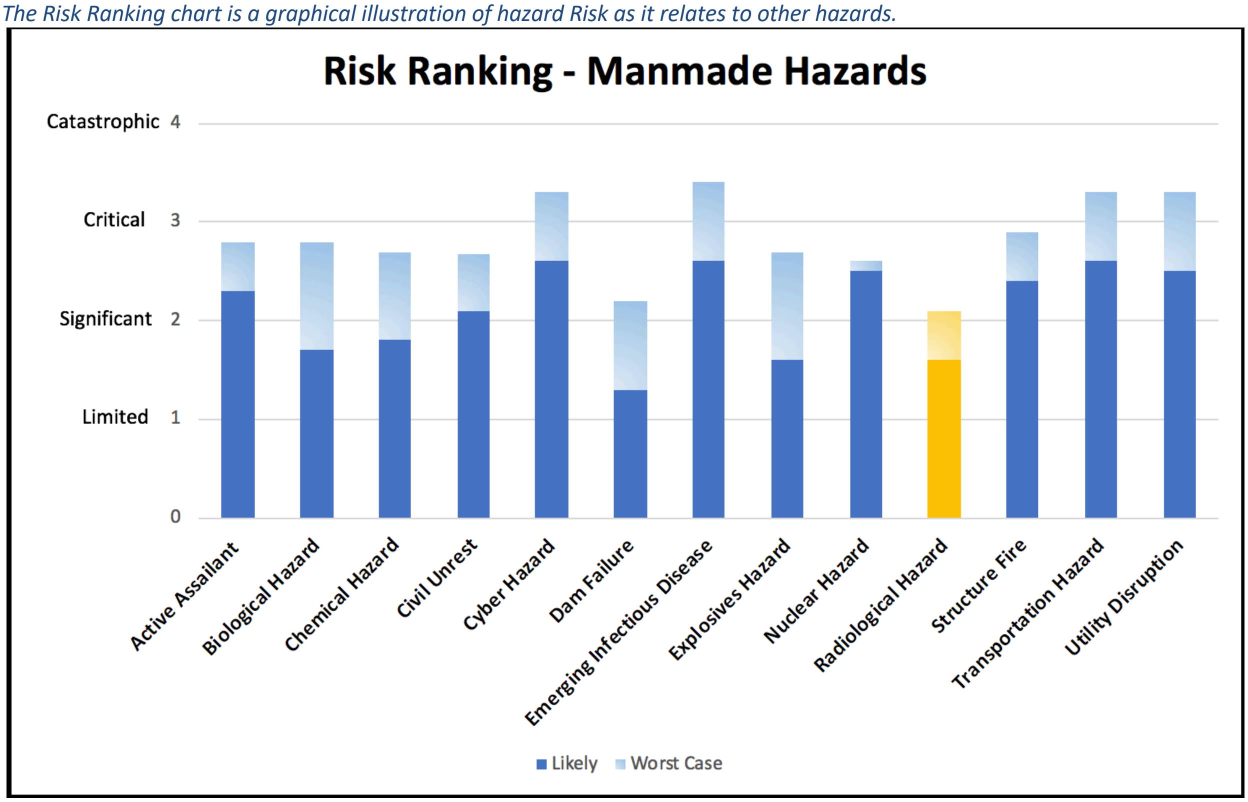
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Radiological Attacks may take several forms. REDs are non-explosive devices containing radioactive material or emitting radiation. REDs are typically concealed in such a manner that people who come into close proximity to the RED receive exposure to radiation. REDs have extremely localized effects and may only affect people who are in physical contact or extremely close proximity to the device.

RDDs, or dirty bombs, use traditional explosives to disperse radioactive material. A dirty bomb blast carries radioactive material into the surrounding area. The area affected by an RDD explosion may range from less than a city block to several square miles. The spread of radioactive materials depends greatly on weather conditions, the type and amount of radioactive material, and the presence of barriers in the surrounding environment. However, most of the impact of a dirty bomb comes from the explosion rather than the radiation, so the area affected is highly dependent on the size of the explosive device. Like REDs, dirty bombs are incapable of creating an atomic blast and should not be confused with improvised nuclear devices. The explosive capacity of a dirty bomb is measured in pounds. This unit of measurement refers to the weight of TNT that would be required to release an equivalent level of explosive energy. The explosive capacity of a dirty bomb can range from 1-10lbs for a small letter bomb, pipe bomb, or small package. A vest or container can contain a bomb with an explosive capacity of up to 20lbs. Cars, SUVs, and minivans can carry bombs with 500-4,000lbs of explosive capacity. A full-sized delivery truck bomb can reach 10,000lbs of explosive capacity.[149]

It is rare to have any advanced warning of a radiological attack. It is possible to have a Radiological Attack take place in a sparsely populated area, but typical Radiological Attack targets include densely populated locations such as office buildings, public gathering areas, special events, commercial areas, and transportation systems. The radiological exposure from a Radiological Attack depends greatly on the type of radioactive material dispersed. Exposure to radiation from a RED or dirty bomb may be minimal. Radiation dose is largely dependent on time, distance, and shielding.

The duration of a Radiological Attack is highly dependent on the mechanism of the attack. A RED may cause exposure for hours or even several days if the low dose of radiation goes unnoticed. A dirty bomb explosive hazard is typically instantaneous. Radioactive material released from the dirty bomb will decay rapidly during the first hours following the explosion. However, it can take several hours to bring the hazard under control and ensure that the area is safe. Secondary hazards such as fire, utility disruption, and transportation disruption may take a day or more to resolve.

[149] For additional information see *IED Attack: Improvised Explosive Devices,* U.S. Dept. of Homeland Security. Available at http://www.dhs.gov/xlibrary/assets/prep_ied_fact_sheet.pdf (last accessed September 27, 2019).

Radiological substances may also be accidentally released into the environment in several different ways. An accident at a nuclear power plant can release a plume of dangerous radiation over an area. Radioactive materials in the plume can settle and contaminate buildings as well as people, food, water, and livestock who are outdoors. Radioactive materials are also commonly transported by trucks and rail, but transportation accidents involving radioactive material rarely result in significant exposure to radiation. Workplace radiation incidents may occur in health care facilities, research institutions, and industrial operations if radiation sources are not stored correctly, safety controls malfunction, or safety procedures are not followed.**Error! Bookmark not defined.**

The area affected by an Unintentional Radiological Substance Release depends greatly on the mechanism of release. A small release may affect a relatively localized site or stretch of road around the release zone. A larger release can easily affect several square miles, especially if radioactive material is spread by wind or water. A major nuclear reactor release can affect many square miles.

Health effects from radiation exposure depend on several factors, including:

- The type and amount of radioactive material released;
- The length of time that people were near the radioactive material, or the length of time the radioactive material was in or on the body;
- The proximity of individuals to the radioactive material or source of radiation; and,
- The parts of the body exposed to radiation.

The duration of an Unintentional Radiological Substance Release hazard depends greatly on the mechanism of release and the type and amount of radioactive material released into the environment. Following a small release of radiological substances, it can take up to 12 hours to remove the hazard and decontaminate the environment. Following a larger release, radiological materials can be present in heavy doses for up to 12 hours while water and soil contamination create an ongoing radiological hazard for days or weeks. Radioactive materials have the potential to cause contamination for months or even years, but an accidental release of this size is extremely unlikely.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

A Radiological Attack may occur anywhere in Howard County. Likely targets for Radiological Attacks in Howard County include densely populated public areas such as schools, commercial facilities, event venues, and office buildings.

The location of Howard County may increase local vulnerability to Radiological Attacks and other terrorism-related attacks. Howard County is in close proximity to valuable terrorist targets including Washington, D.C., the City of Baltimore, the Port of Baltimore, and BWI Airport. Due to its proximity to the NCR, many Federal agencies, defense contractors, and high-profile targets maintain facilities within Howard County.[150]

Unintentional Radiological Substance Release Hazards are most likely to occur in areas where radiological substances are frequently kept or transported. Radiological substances may be present in many of the medical centers and research facilities in and around Howard County. Radiological substances are transported through Howard County, making areas near railways and major roadways particularly vulnerable to Unintentional Radiological Substance Release Hazards. There are no nuclear power plants in Howard County. Due to the distance of Howard County from PBAPS (i.e., within 50-miles), it is likely that the County and residents may be impacted should there be a radiological emergency at PBAPS. Protective Actions that may be implemented following an emergency at PBAPS are:

- Evacuating an area
- Sheltering-in-place within a building or protective structure
- Administering potassium iodide (KI) as a supplemental action
- Relocation
- Acquiring an alternate source of drinking water, and
- Interdiction of food/milk.

[150] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

Howard County is within 50 miles of PBAPS in York County, PA, 100 miles of CCNPP in Calvert County, MD, and 110 miles from Three Mile Island Nuclear Generation Station in Dauphin County, PA. While it is important to note all of the nearby nuclear power plants, it is essential to plan for and understand the unique consequences of being within a 50-mile radius of any nuclear power plant.

Additionally, it is important to note that in the 2015 HIRA, Radiological Hazards were reviewed separately as “Radiological Attacks” and “Unintentional Radiological Substance Release”. In the updated 2019 HIRA, Radiological Hazards have been expanded to include all Radiological Hazards, both intentional and unintentional. Due to this expansion, there may be a higher number of events reported in the occurrence of the hazard due to more events falling within the definition of the hazard.

There have been zero Radiological Attack hazard events in Howard County during the reviewed time period (1996-2019). Additionally, there have been zero Unintentional Radiological Substance Release hazard events in Howard County between 1996-2016. However, in 2017, there were two incidents reported. During the first incident, radiation was detected from improperly disposed of smoke detectors. During the second incident, radiation was detected from an improperly transported earth density gauge. There was an estimated total of two Radiological Hazard events during the reviewed time period of 1996-2019.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

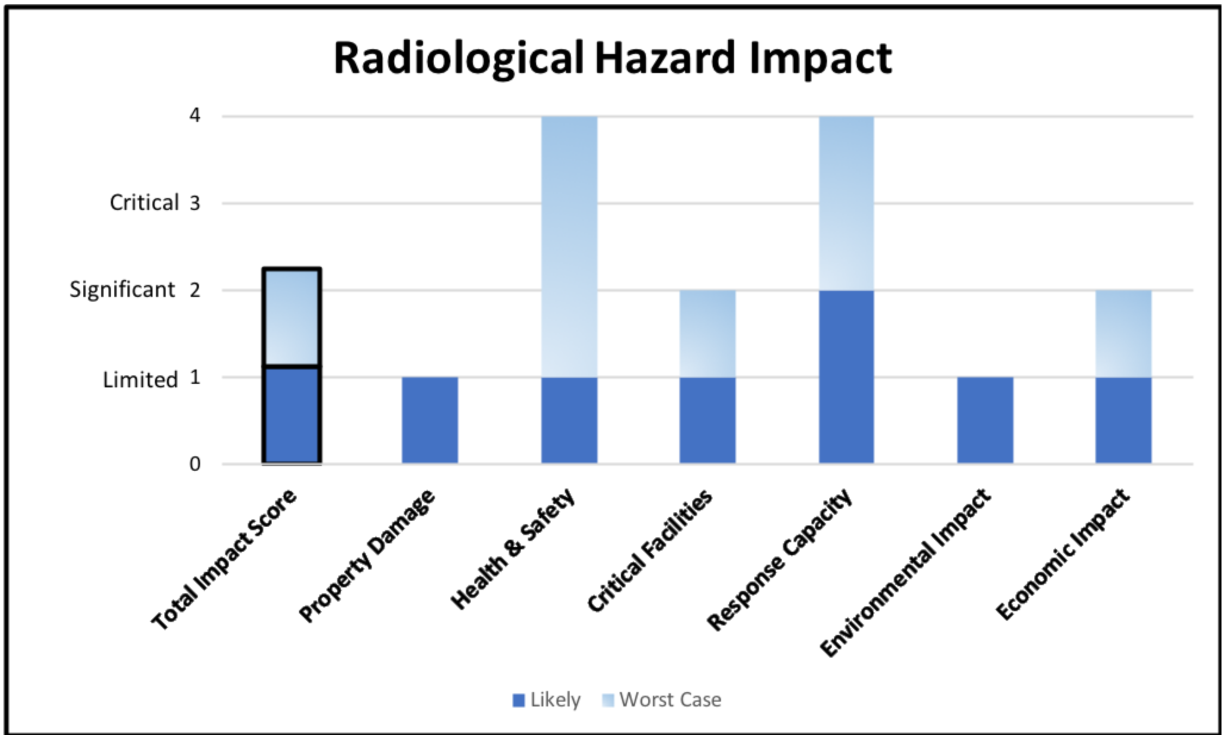
Future Likelihood of a Radiological Hazard in Howard County	
Historical Average (time period)	2 recorded events (1996-2019)
Historical Annual Probability	1-10% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	1-10% chance of annual occurrence
Future Likelihood Score	1.875 (Unlikely-Infrequent)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: The future annual probability of the hazard is 1-10% chance of annual occurrence, or, one event 10- 99 years. Howard County has never experienced a Radiological Attack, but several factors should be considered when weighing the future likelihood of an attack. Radiological Attacks in the U.S. and abroad demonstrate the possibility of a successful attack inside Howard County. The increased threat of terrorism and the County's proximity to high value terrorist targets also contribute to a slight increase in the likelihood of a Radiological Attack in the future. Other considerations include the County's proximity to labs, medical facilities, power plants, and other facilities that have radiological materials.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Radiological Hazard Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time.	*Short.* No warning time prior to an attack unless a “group” provides a warning/threat.
DURATION	*Moderate.* Hazard onset is nearly instantaneous. It may take six to 12 hours to declare the hazard location safe.	*Long.* Hazard onset is nearly instantaneous. It may take up to 72 hours for emergency response, longer for Law Enforcement investigation.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Radiological Hazard Consequence Analysis **Likely**		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure.
HEALTH AND SAFETY	*Limited*	▪ Zero deaths likely. ▪ Zero injuries likely.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Delays unlikely.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Local resources adequate. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state or Federal assistance. There will likely be long-lasting impact to hazardous materials response capabilities. ▪ *Health* – Local resources adequate. HD operations will not be affected. ▪ *Hospitals* – Local resources adequate. No major impact to the hospital system. Hospital decontamination will likely be unnecessary if decontamination takes place at the site. ▪ *Emergency Management* – Moderate need for state or Federal assistance. Significant planning support may be necessary for hazardous materials cleanup and terrorism investigation.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact. The radiation will likely disburse rapidly from the environment, and consequences to air, water, and land should be limited.
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. Other costs include cleanup and healthcare for those affected. ▪ Zero jobs lost.
TOTAL IMPACT[151]	***Limited***	▪ **Total Impact Score: 1.1 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[151] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

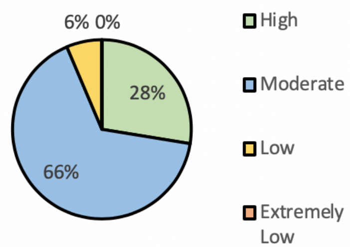
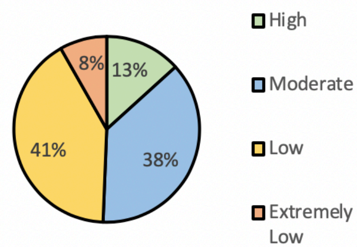
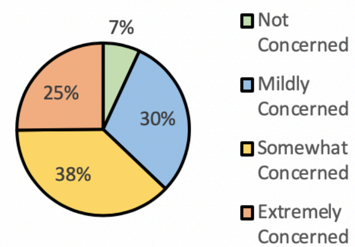
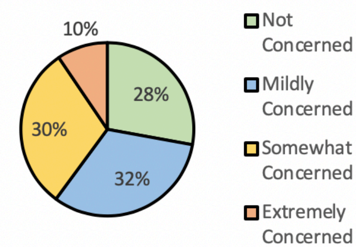
Radiological Hazard Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ Significant damage to critical and non-critical infrastructure. ▪ The explosion from a large radiological dispersion device could be sufficient to cause building collapse. The attack may cause superficial damage to property and structures within several blocks of the attack site. Most of the property damage from a Radiological Attack hazard will be the result of the explosive rather than the radiation.
HEALTH AND SAFETY	*Catastrophic*	▪ 50-100 deaths likely and 100-300 injuries likely. ▪ The number of deaths and injuries is largely dependent on the population density at the site of the attack. Deaths and injuries are most likely due to trauma from the explosive blast rather than the radiation.
CRITICAL FACILITIES	*Significant*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Delays for three to five days. Major transportation delays will be caused by people exiting the surrounding area. Major closures will occur in the immediate aftermath of the attack, and localized transportation routes will be closed for days.
RESPONSE CAPACITY	*Catastrophic*	▪ *Police* – Mutual aid needed. Terrorism response automatically triggers Federal law enforcement involvement. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Significant and long-lasting need for state or Federal assistance. There will likely be long-lasting impact to hazardous materials response capabilities. Regional EMS resources will be overwhelmed. ▪ *Health* – Moderate need for state or federal assistance. Regular HD operations will not be affected. Health Emergency Preparedness, Communicable Diseases, and Environmental Health functions will be altered. ▪ *Hospitals* – Mutual aid needed. Howard County General Hospital is not a trauma center, resulting in the need to divert all explosive blast injuries to other hospitals. A large influx of psychological casualties (worried well) may strain the hospital. ▪ *Emergency Management* – Moderate need for state or federal assistance. Significant planning support may be necessary for hazardous materials cleanup and terrorism investigation. There is no significant impact to Emergency Management Continuity of Operations.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact. The radiation will likely disburse rapidly from the environment, and consequences to air, water, and land should be limited. Lasting environmental impact will be minimal, but public perceptions of environmental danger may significantly outlast any actual environmental impact.
ECONOMIC IMPACT	*Significant*	▪ Minimal loss of economic output due to the limited area affected. Other costs include cleanup and healthcare for those affected. ▪ Temporary job loss is likely in the impacted area. Significant impact on Howard County image.
TOTAL IMPACT[152]	***Significant - Critical***	▪ **Total Impact Score: 2.25 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[152] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes public perceptions of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
 *Average: 3.21* *Moderate - High*	 *Average: 2.56* *Low - Moderate*	 *Average: 2.81* *Mildly Concerned - Somewhat Concerned*	 *Average: 2.22* *Mildly Concerned - Somewhat Concerned*

Structure Fire

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

A Structure Fire is an uncontrolled fire involving a building or structure. Structure Fires can occur in a residential, commercial, or industrial setting. Fires can easily spread from one structure to others nearby, and the size of a structure fire hazard is constantly evolving, until contained. Structure Fires can be caused intentionally or unintentionally, but often the origin of the fire is not known until after the hazard has been brought under control.

Risk Profile

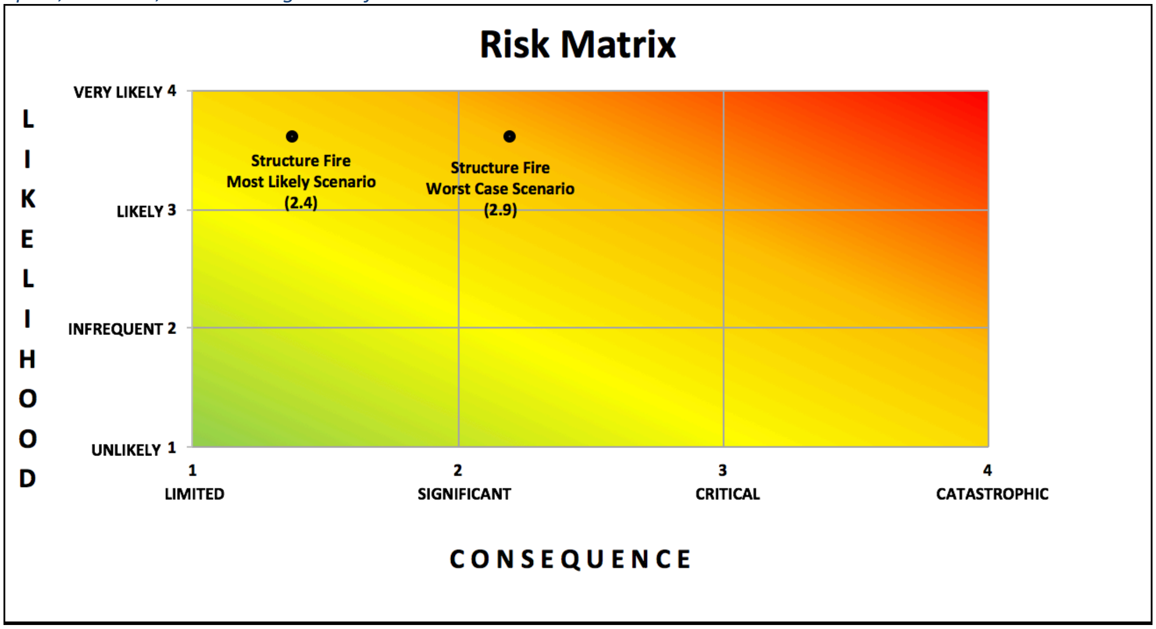
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Structure Fire Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	3.6 Likely- Very Likely		50%
CONSEQUENCE	**Impact**	1.1 Limited	2 Significant	40%
	Warning Time	4 Short	4 Short	5%
	Duration	1 Short	2 Moderate	5%
TOTAL RISK SCORE		**2.4**	**2.9**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

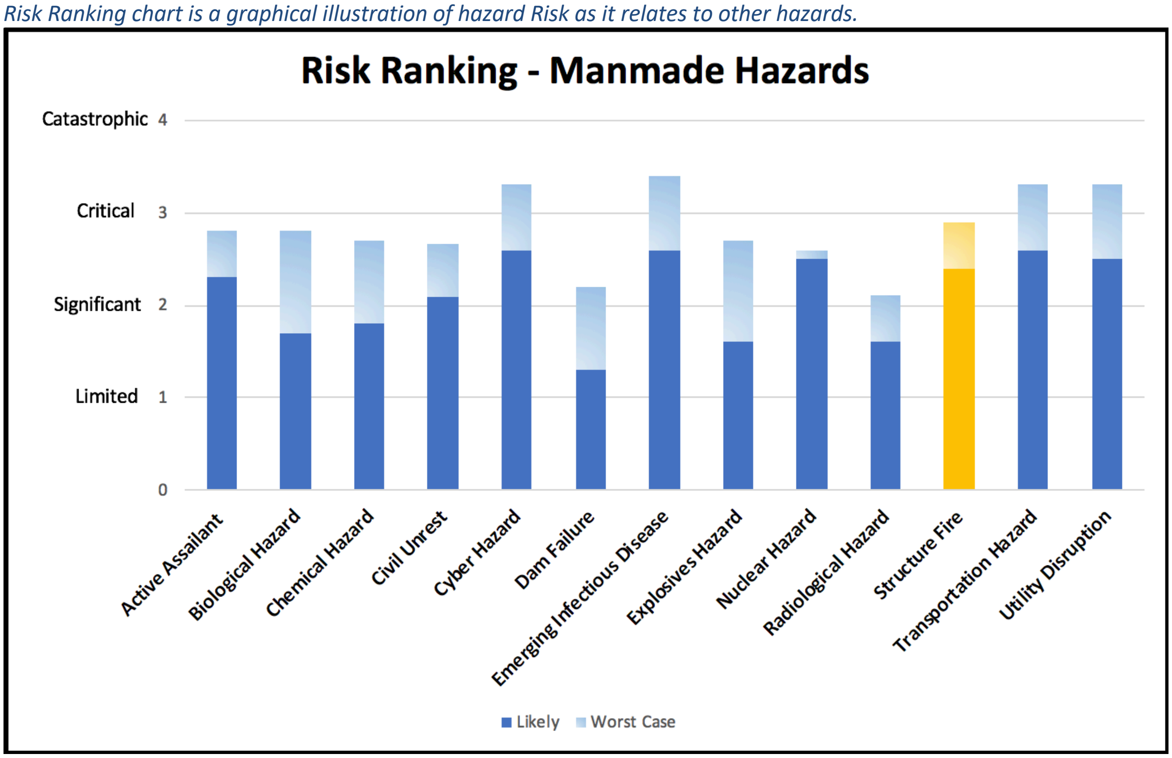
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

A Structure Fire can occur in nearly any manmade structure and may involve a single building or many structures over multiple city blocks. The number of people affected depends greatly on the type of structure involved and the population density within. Fires may affect vacant structures, residential homes, or highly populated commercial areas or apartment buildings. People occupy commercial and industrial structures more densely during the day and residential structures more densely at night, so the time of day a hazard occurs directly impacts the number of people affected by a fire in any given structure. Vulnerability to Structure Fire Hazard is highly dependent on the type of construction involved and the fire-prevention safeguards incorporated into the design. The International Building Code categorizes constructions into five types based on their level of fire resistance:

- *Type I and II: Fire Resistive/Noncombustible* – Building elements are of noncombustible materials. Examples of Type I and Type II construction include modern commercial structures and high-rise buildings built with concrete, protected steel, reinforced masonry, and other noncombustible materials.
- *Type III*: *Ordinary* – Exterior walls are of noncombustible materials. Interior building elements may consist of other materials permitted by code. Examples of Type III construction include older buildings with unreinforced masonry walls and conventional wood roofs.
- *Type IV: Heavy Timber* – Exterior walls are of noncombustible materials, and the interior building elements are of solid or laminated wood without concealed spaces. Examples of Type IV construction include older buildings that use large-dimensional lumber for structural support.
- *Type V: Wood-Framed* – Structural elements, exterior, and interior walls are of any materials permitted by code. Construction may include fire-resistant and non-fire-resistant materials. Examples of Type V construction include modern homes with combustible wood-framed walls and roofs.

It is rare to have any advanced warning of a Structure Fire Hazard. Structure Fires may take anywhere from several hours to a day or more to extinguish. Structure Fire Hazards caused by large wildland fires can take multiple days to extinguish.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

A Structure Fire may occur anywhere where structures are located in Howard County. Areas that are densely populated and densely developed are particularly vulnerable to Structure Fires. Structure Fires may spread rapidly in locations with congested infrastructure. Although many structures in Howard County were built relatively recently, there are also many historic areas where construction is unlikely to comply with all modern fire safety laws and regulations.[153]

[153] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

Structure Fires have environmental impacts that may affect the air, water, and soil quality of our region, specifically, carbon reduction. However, during a fire, this reduction in carbon may be negated due to the additional carbon emitted into the environment through combustion of building contents.

There were 3,468 Structure Fire responses in Howard County between (2008-2019).[154] The following reflects data from the past five years:

- In 2014, DFRS responded to 222 reported Structure fires resulting in $7,602,506[155] loss additionally, two citizens lost their lives during these incidents and seven were injured.[156]
- In 2015, DFRS responded to 239 reported Structure fires resulting in $7,349,646[157] loss additionally, no citizens lost their lives during these incidents and nine were injured.[158]
- In 2016, DFRS responded to 246 reported Structure fires resulting in $8,863,033[159] loss, no citizens lost their lives during these incidents and 17 were injured.[160]
- In 2017, DFRS responded to 296 reported Structure fires resulting in $7,011,828[161] loss, additionally zero citizens lost their lives during these incidents and 19 were injured.[162]
- In 2018, DFRS responded to 243 reported Structure fires resulting in $10,375,345[163] loss, additionally zero citizens lost their lives during these incidents and 16 were injured.[164][165]

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[154] *Howard County CAD Report 1/01/2008 – 12/31/2013 (unpublished)*, Howard County DFRS (2014). (*See also*, Howard County Department of Fire and Rescue Services, 2019).
[155] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2014 was $7,015,127. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[156] Howard County Department of Fire and Rescue Services, 2019.
[157] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2015 was $6,789,853. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[158] Howard County Department of Fire and Rescue Services, 2019.
[159] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2016 was $8,291,264. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[160] Howard County Department of Fire and Rescue Services, 2019.
[161] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2017 was $6,699,224. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[162] Howard County Department of Fire and Rescue Services, 2019.
[163] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2018 was $10,154,904. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[164] Howard County Department of Fire and Rescue Services, 2019.
[165] While the review period continued until 2019, the data we received from Subject Matter Experts did not include 2019 data.

Notable Incidents in Howard County

The large majority of Structure Fires in Howard County are residential cooking-related fires.

1999 Ellicott City Fire – A 6-alarm fire destroyed multiple businesses in downtown Ellicott City. The fire took several hours to contain and caused over $1.5 million[166] in damage.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Structure Fire in Howard County	
Historical Average (time period)	3468 events (2008-2018)
Historical Annual Probability	100% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	100% chance of annual occurrence
Future Likelihood Score	3.625 (Likely- Very Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

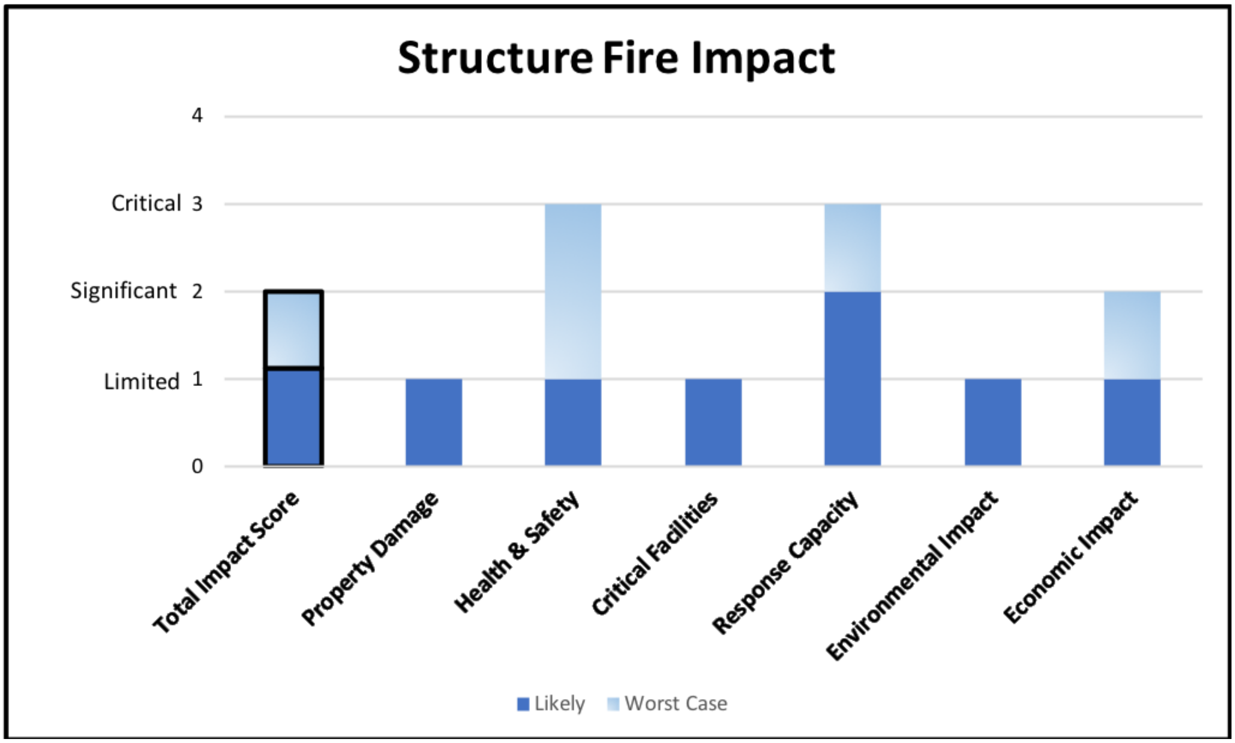
Considerations: The future likelihood of Structure Fires in Howard County is not expected to be significantly different from the historical occurrence rate. A future annual probability of 100% classifies the likelihood of a Structure Fires as Very Likely, or, one event every year. Increases in population density and development density will increase the number of structures available to burn. However, fire prevention safeguards built into modern constructions are expected to contribute to a slight decline in the overall likelihood of Structure Fires in the future.[153]

[166] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 1999 was $1 million Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Structure Fire Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time prior to the onset of the hazard.	*Short.* No warning time prior to the onset of the hazard.
DURATION	*Short.* Two to six hours to remove the hazard and declare the hazard location safe.	*Moderate.* 12-24 hours to remove the hazard and declare the hazard location safe.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Structure Fire Consequence Analysis Likely		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ There is damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely. Localized fire and water damage are likely for structures involved in the fire.
HEALTH AND SAFETY	*Limited*	▪ Zero deaths likely. ▪ One to two injuries likely. ▪ Fire deaths and injuries are likely due to smoke inhalation, burns, or trauma due to structural collapse.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure ▪ *Transportation* – Delays for less than six hours. Impacts to transportation will be minor and short-term. Road closures will be extremely localized, and delays will not be excessive.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Local resources adequate. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Mutual aid needed. Necessary mutual aid coverage should be readily available. No impact on response capability or Continuity of Operations. ▪ *Health* – Local resources adequate. HD operations will not be affected. ▪ *Hospitals* – Local resources adequate. No impact on the hospital system. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact. Less than a day of clean-up. Impact to a localized area. Minimal localized air pollution may result from the burning of wood and synthetic materials. Air pollution will likely dissipate rapidly once the fire has been extinguished.
ECONOMIC IMPACT	*Limited*	▪ Minimal loss of economic output due to the limited area affected. Other costs include cleanup and healthcare for those affected. ▪ Zero jobs lost.
TOTAL IMPACT[167]	***Limited***	▪ **Total Impact Score: 1.125 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[167] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

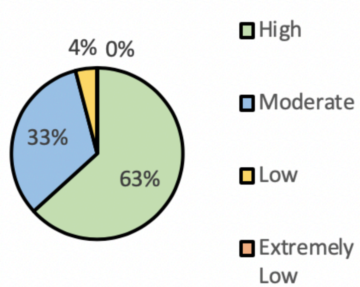
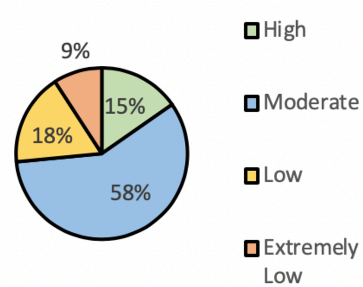
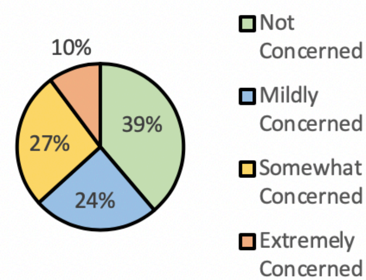
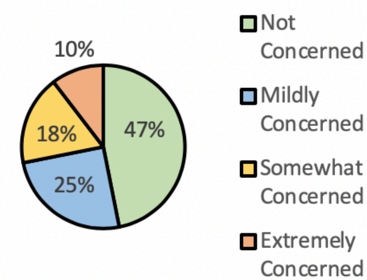
The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

Structure Fire Consequence Analysis Worst-Case				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Limited*	▪ There is damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely. Localized fire and water damage are likely for structures involved in or in close proximity to the fire.		
HEALTH AND SAFETY	*Critical*	▪ 10-20 deaths likely. ▪ 50+ injuries likely. ▪ Fire deaths and injuries are likely due to smoke inhalation, burns, or trauma due to structural collapse.		
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Diminished water capacity for the duration of fire suppression efforts (12-24 hours). Water supply to homes and businesses will remain functional at a diminished capacity in the localized hazard area due to fire suppression efforts. Water for fire suppression activities will become scarce if suppression activities continue for an extended period of time. ▪ *Information/Communications* – No shutdown. No major impact on information or communications infrastructure. ▪ *Transportation* – Delays for up to one day. Impacts to transportation will be minor and short-term. Road closures will be localized, and delays will not be excessive.		
RESPONSE CAPACITY	*Critical*	▪ *Police* – Local resources adequate. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state assistance. Sustained fire suppression activities will strain emergency service delivery. Substantial mutual aid resources will be necessary to stabilize the hazard and maintain regular service coverage. ▪ *Health* – Mutual aid needed. Regular HD operations will not be affected. Health Emergency Preparedness might be necessary to support the emergency response. ▪ *Hospitals* – Local resources adequate. The Emergency Department would be very busy treating injuries from the Structure Fire hazard. Additional resources may be needed if the number of patients exceeds Emergency Department capacity. Mass casualty and triage activities may be necessary, but plans are in place to manage a patient surge of this size. Major disruption of regular hospital activities is unlikely. ▪ *Emergency Management* – Moderate need for state assistance. Limited impact to Emergency Management capability.		
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact. Less than a day of clean-up. Impact to a localized area. Moderate localized air pollution may result from the burning of wood and synthetic materials. Air pollution will likely dissipate rapidly once the fire has been extinguished.		
ECONOMIC IMPACT	*Significant*	▪ Significant loss in economic output. Other costs include cleanup and healthcare for those affected. ▪ Business activities will be impacted in a localized area near the hazard.		
TOTAL IMPACT[168]	***Significant***	▪ **Total Impact Score: 2 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

[168] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Structure Fire Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
			
Average: 3.59 Moderate - High	*Average: 2.80 Low - Moderate*	*Average: 2.08 Mildly Concerned - Somewhat Concerned*	*Average: 1.92 Not Concerned - Mildly Concerned*

Transportation Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

A Transportation Hazard occurs whenever a vehicle accident or collision occurs, or an incident involving transportation modes has the potential to cause harm. Any vehicle is capable of being involved in a Transportation Hazard. The most common types of Transportation Hazards involve automobiles, trains, airplanes, or boats. A Transportation Hazard can involve one or multiple vehicles, and cascading effects may include the release of hazardous materials (profiled separately in Chemical, Biological, and Radiological Hazards).

Risk Profile

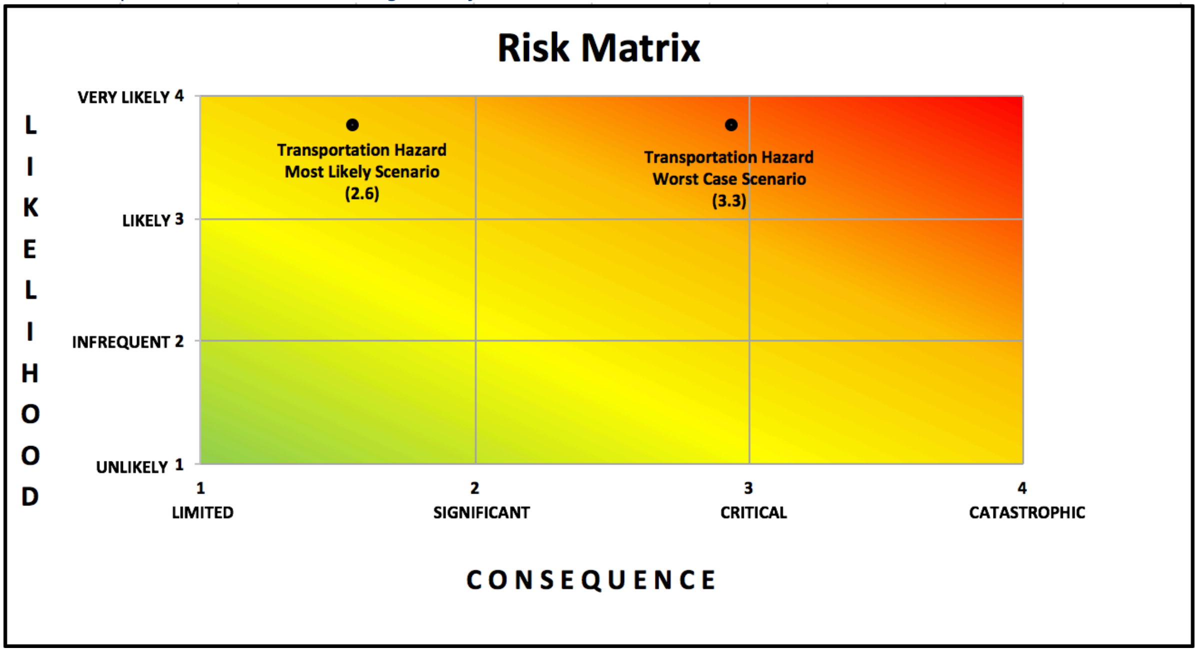
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

<table>
<tr><th colspan="5">Transportation Hazard
Risk Profile</th></tr>
<tr><td rowspan="2">LIKELIHOOD</td><td>Risk Assessment Category</td><td>Likely Hazard Scenario</td><td>Worst-Case Hazard Scenario</td><td>Weight</td></tr>
<tr><td>Likelihood</td><td colspan="2">3.75
Likely- Very Likely</td><td>50%</td></tr>
<tr><td rowspan="3">CONSEQUENCE</td><td>Impact</td><td>1.2
Limited-Significant</td><td>2.8
Significant-Critical</td><td>40%</td></tr>
<tr><td>Warning Time</td><td>4
Short</td><td>4
Short</td><td>5%</td></tr>
<tr><td>Duration</td><td>2
Moderate</td><td>3
Long</td><td>5%</td></tr>
<tr><td colspan="2">TOTAL RISK SCORE</td><td>2.6</td><td>3.3</td><td></td></tr>
</table>

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

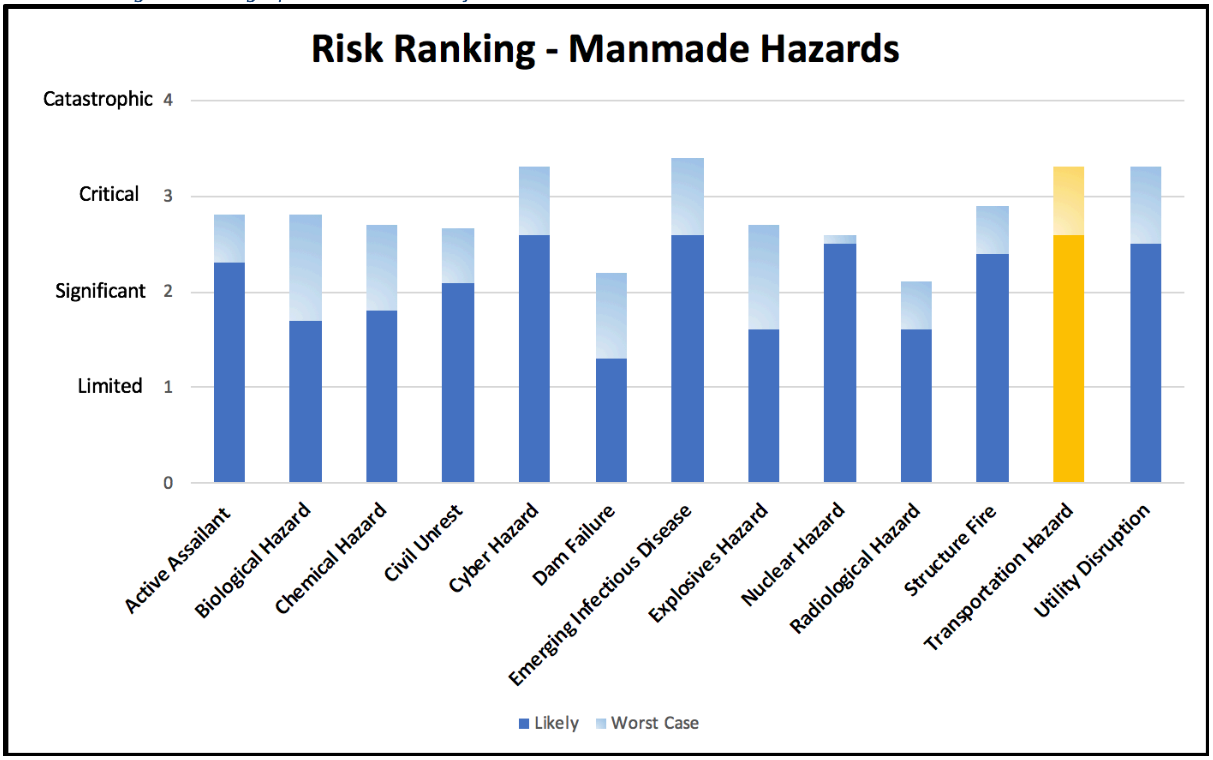
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

A Transportation Hazard can involve road vehicles, trains, airplanes, or boats, and the characteristics of the hazard depend greatly on the vehicles involved. The hazard may involve one vehicle or many vehicles. Although a Transportation Hazard can occur nearly anywhere, affected areas are typically in close proximity to roadways, railways, or other locations with high levels of vehicle traffic areas. Because dangerous substances are often moved from one place to another via truck, train, or ship, Transportation Hazards can involve the release of hazardous materials including combustible, explosive, radiological, biological, or otherwise toxic substances. It is rare to have any advanced warning of a Transportation Hazard event. Transportation Hazards typically occur over the span of seconds or minutes. Secondary hazards such as fire, transportation disruption, and the release of hazardous materials may take several hours to bring under control. Additionally, the likelihood of a transportation hazard may increase by external factors such as inclement weather, congested roads, or unsafe road conditions.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

A Transportation Hazard can occur anywhere in Howard County. Transportation Hazards are most likely to occur along heavily trafficked transportation routes. Areas along major arterial roads and interstate highways are especially vulnerable to Transportation Hazards involving road vehicles. The eastern portion of Howard County experiences the highest levels of road traffic, averaging several hundred thousand vehicles daily.[169] This is primarily due to road networks within that area. The eastern portion of Howard County has larger interstates and a more crowded population traveling though those road networks.

There are many areas in Howard County where a train-caused Transportation Hazard can occur. There is a heavily-trafficked freight rail line that runs along most of Howard County's northern border. Trains on this line intersect major road transportation routes and travel through several urban and suburban communities. The MARC Camden Line commuter train also passes through western Howard County many times a day on its path between the City of Baltimore and Washington, D.C.

Aviation Transportation Hazards are a possibility in Howard County. Although there are no active airports in Howard County, airplanes frequently fly low over the western portion of the County on approach to BWI Airport. Given the high volume of air traffic above Howard County and the proximity to multiple high-traffic airports, an aviation hazard can occur anywhere inside the planning area.

Transportation Hazards involving water vehicles are unlikely. There are no large bodies of water in Howard County, and the small lakes and reservoirs within the planning area do not allow motorized water vehicles.[170]

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

There have been 786 Transportation Hazard responses requiring extrication or rescue and an additional 960 vehicle fire responses in Howard County between 2008-2013.[171] There were over 182 Transportation Hazard responses conducted by DFRS between 2014-2018.[172] In total, there were a combined 1,928 Transportation Hazard events during the review period of 2008-2018.[173]

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169 MDOT; SHA. Traffic Volume Maps by County. Retrieved from https://www.roads.maryland.gov/Index.aspx?PageId=792. *See also*: MDOT; SHA. (2019). 2018 Traffic Volume Maps . Retrieved from https://www.roads.maryland.gov/Traffic_Volume_Maps/Traffic_Volume_Maps.pdf#page=1&zoom=100.

170 *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).
171 *Howard County CAD Report 1/01/2008 – 12/31/2013 (unpublished)*, Howard County DFRS (2014).
172 While the review period continued until 2019, the data we received from Subject Matter Experts did not include 2019 data.
173 While the review period continued until 2019, the data we received from Subject Matter Experts did not include 2019 data.

Most Transportation Hazards in Howard County involve a small number of passenger vehicles, and only a very small percentage of accidents result in fatalities.

Notable Incidents in Howard County

1962 Ellicott City Aircraft Crash – United Airlines Flight 297 collided with a flock of swans while preparing to land at Washington National Airport. The aircraft lost control and broke apart mid-air, crashing outside of Ellicott City and killing all 17 people aboard the plane.

1982 Columbia Aircraft Crash – A Beech D95A crashed in Columbia as a result of pilot error. Five people died in the accident.

2012 Ellicott City Train Derailment – A CSX freight train derailed as it was passing over the bridge in downtown Ellicott City. The cause of the accident was unclear. A total of 21 rail cars went off their tracks, fatally burying two bystanders. The derailment caused an estimated $2.4 million[174] in damage.

2014 Diesel Spills – DFRS responded to over 30 incidents involving large trucks leaking diesel fuel incl. During this time over 600 gallons of fuel leaked onto the road or the adjoining earth. During these responses, Special Operations removed over 1,800 gallons of fuel from leaking tanks further preventing environmental contamination.[175] In addition, DFRS also responded to another diesel fuel spill in North Laurel. 300 gallons of diesel fuel leaked from the damaged tractor trailer involved in accident and fire. This event resulted in one death and one injury.

2015 Diesel Spills – DFRS responded to over 28 incidents involving large trucks leaking diesel fuel. During this time over 127 gallons of fuel leaked onto the road or the adjoining earth. During these responses, Special Operations removed over 645 gallons of fuel from leaking tanks further preventing environmental contamination.[176]

2016 Diesel Spills – DFRS responded to over 67 incidents involving large trucks leaking diesel fuel. During this time over 195 gallons of fuel leaked onto the road or the adjoining earth. During these responses, Special Operations removed over 1,340 gallons of fuel from leaking tanks further preventing environmental contamination.[177]

2017 Diesel Spills – DFRS responded to over 32 incidents involving large trucks leaking diesel fuel. During this time over 411 gallons of fuel leaked onto the road or the adjoining earth. During these responses,

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[174] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2012 was $2.2 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

[175] Howard County Department of Fire and Rescue Services, 2019.
[176] Howard County Department of Fire and Rescue Services, 2019.
[177] Howard County Department of Fire and Rescue Services, 2019.

Special Operations removed over 1,400 gallons of fuel from leaking tanks further preventing environmental contamination. There is one recorded death for this time period.[178]

2018 Diesel Spills – DFRS responded to over 25 incidents involving large trucks leaking diesel fuel. During this time over 640 gallons of fuel leaked onto the road or the adjoining earth. During these responses, Special Operations removed over 2,800 gallons of fuel from leaking tanks further preventing environmental contamination.[179]

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Transportation Hazard in Howard County	
Historical Average (time period)	Estimated 1928 events (2008-2018)
Historical Annual Probability	100% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	100% chance of annual occurrence
Future Likelihood Score	3.75 (Likely- Very Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

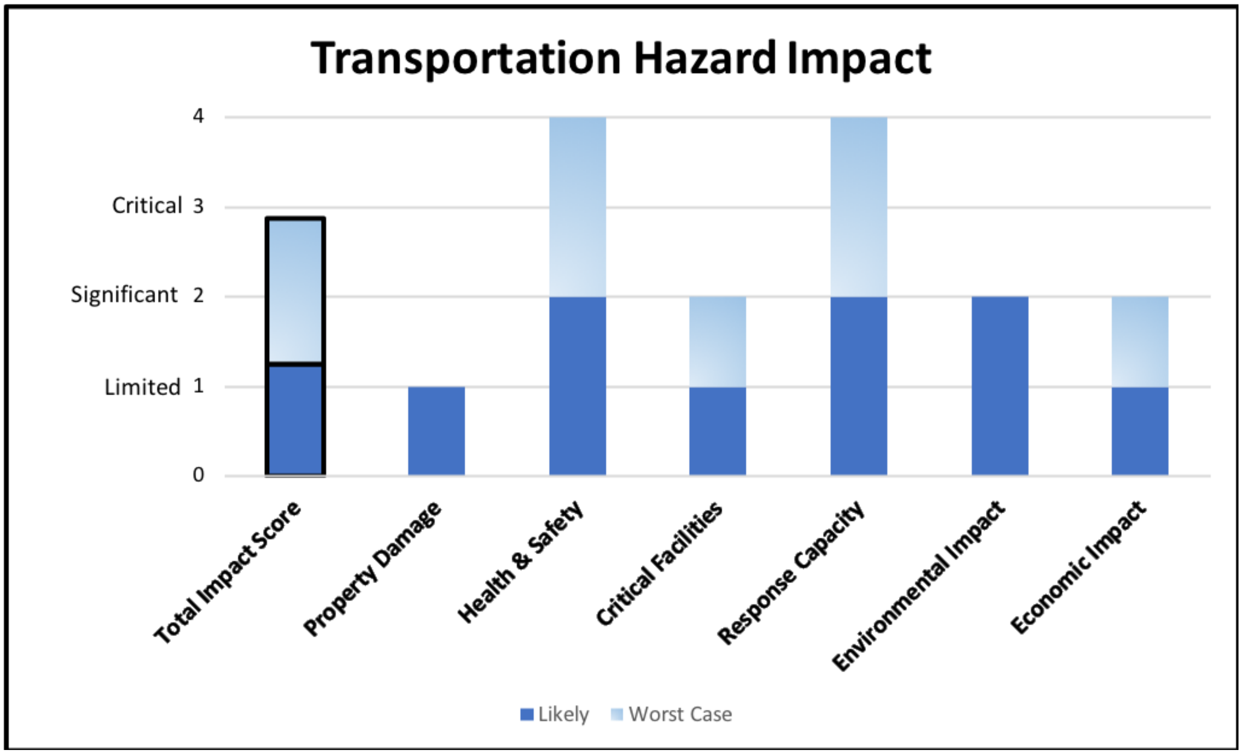
Considerations: The future likelihood of a Transportation Hazard in Howard County is not expected to be significantly different from the historical occurrence rate. A future annual probability of 100% classifies the likelihood of a Transportation Hazard as Very Likely or one event every year. The growing population and increase in motor vehicle traffic is expected to result in a slight increase in the likelihood of Transportation Hazard over time.[170] Other considerations include an increase in texting and driving.

[178] Howard County Department of Fire and Rescue Services, 2019.
[179] Howard County Department of Fire and Rescue Services, 2019.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Transportation Hazard Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time prior to the onset of the hazard.	*Short.* No warning time prior to the onset of the hazard.
DURATION	*Moderate.* Two hours to stabilize the hazard. Up to 12 -15 hours to declare the hazard location safe and return to pre-hazard conditions.	*Long.* 12 hours to stabilize the hazard. Up to one week to declare the hazard location safe and return to pre-hazard conditions.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Transportation Hazard Consequence Analysis Likely				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely. Minor damage may occur to property in a localized area around the hazard.		
HEALTH AND SAFETY	*Significant*	▪ One to four deaths likely. ▪ Six to eight injuries likely. Injuries may involve: Inhalation hazard, easily ignitable, dizziness, and suffocation potential. ▪ Physical trauma is the most common cause of injury and death in a Transportation Hazard event.		
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown unlikely. No effect on utilities. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Delays are to be expected. Impacts to transportation will be minor and short-term. Road closures will be extremely localized, and delays will not be excessive.		
RESPONSE CAPACITY	*Significant*	▪ *Police* – Local resources adequate. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Mutual aid needed. Some mutual aid assistance required. ▪ *Health* – Local resources adequate. HD operations will not be affected. ▪ *Hospitals* – Local resources adequate. No impact on the hospital system. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.		
ENVIRONMENTAL IMPACT	*Significant*	▪ Limited to significant environmental impact. Hazardous liquid spills may cause soil contamination and water pollution in a localized area. If hazardous materials enter nearby waterways, the contamination may extend beyond a localized area. ▪ There are significant pollution/environmental impacts.		
ECONOMIC IMPACT	*Limited*	▪ There is loss in economic output. Other costs include cleanup and healthcare for those affected. ▪ Limited impact to local businesses.		
TOTAL IMPACT[180]	***Limited-Significant***	▪ **Total Impact Score: 1.25 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

[180] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

Transportation Hazard Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ There is damage to critical and non-critical infrastructure. ▪ There is significant damage to buildings, property, and infrastructure in the hazard area for a half mile area around the crash.
HEALTH AND SAFETY	*Catastrophic*	▪ 100-200 deaths likely and 20 injuries likely. ▪ Physical trauma is the most common cause of injury and death in a Transportation Hazard event. Large-scale automobile or train hazards will likely result in a high number of injuries, while an aircraft crash hazard will likely result in fewer injuries and many more deaths.
CRITICAL FACILITIES	*Significant*	▪ *Utilities* – Utilities will be disrupted for the duration of fire suppression efforts (up to 12 hours). Extended fire suppression efforts will result in diminished (but functional) water supply to homes and businesses in a localized area. ▪ *Information/Communications* – No shutdown. No major impact on information or communications infrastructure. ▪ *Transportation* – Delays for several days. Public mobility will be severely impacted in the immediate aftermath of the hazard event. Major transportation arteries will be closed, and diverted traffic will cause extensive delays.
RESPONSE CAPACITY	*Catastrophic*	▪ *Police* – Significant need for state or federal assistance. Federal agencies will require their own investigations. ▪ *Fire and Rescue* – Significant and long-lasting need for state or federal assistance. Response will strain local resources. Various mutual aid response operations will be necessary. ▪ *Health* – Local resources adequate. HD operations will not be affected. ▪ *Hospitals* – Mutual aid needed. Patient surge would put some strain on the Emergency Department, but there would be no great impact on hospital emergency functions. ▪ *Emergency Management* – Significant need for state and federal assistance. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Significant*	▪ Significant environmental impact. Some loss wildlife, vegetation, and short-term pollution is likely. Limited air pollution may result from the burning of materials. Hazardous liquid spills may cause soil contamination and water pollution. The water pollution may kill aquatic life in the nearby waterways. The soil contamination and water pollution may have impacts beyond the immediately affected area if the leak is located within the Patuxent Reservoirs watershed (a surface drinking water supply source) or the recharge area of a groundwater drinking water supply source.
ECONOMIC IMPACT	*Significant*	▪ There is significant loss economic output. Other costs include cleanup and healthcare for those affected. ▪ Many jobs are lost. ▪ Businesses will be impacted in the wider crash area.
TOTAL IMPACT[181]	***Significant - Critical***	▪ **Total Impact Score: 2.875 on a scale of 1 (Limited) to 4 (Catastrophic).**

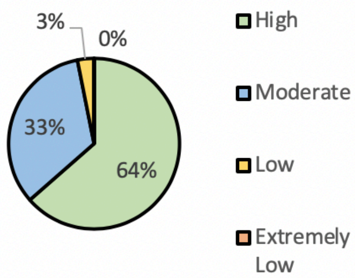
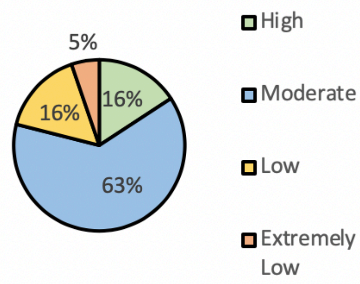
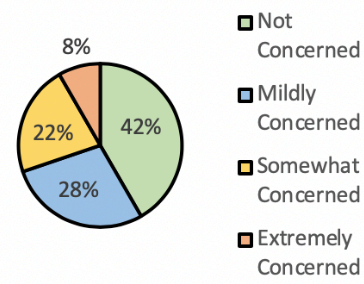
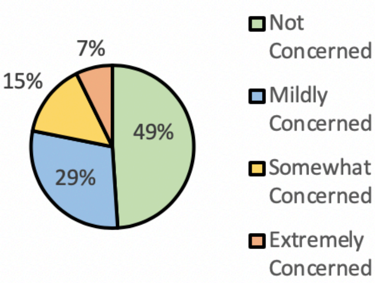
Limited	*Significant*	*Critical*	*Catastrophic*

[181] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Transportation Hazard
Public Perception

PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD	CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY	CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY
			
Average: 3.60 *Moderate - High*	*Average: 2.89* *Low - Moderate*	*Average: 1.97* *Not Concerned - Mildly Concerned*	*Average: 1.80* *Not Concerned - Mildly Concerned*

Utility Disruption

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

A Utility Disruption occurs when the disruption of the gas, water, or electrical infrastructure has the potential to cause harm. Utility Disruptions can be intentional, unintentional, or occur as a cascading effect of another hazard.

Risk Profile

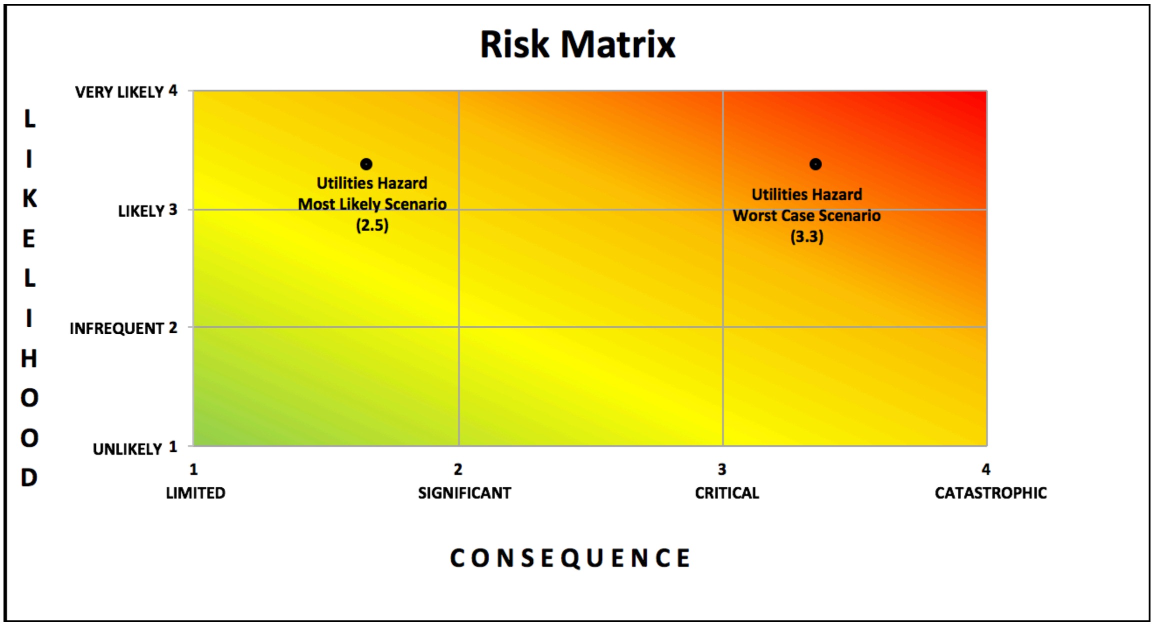
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Utility Disruption Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	3.37 Likely- Very Likely		50%
CONSEQUENCE	**Impact**	1.2 Limited-Significant	3.2 Critical-Catastrophic	40%
	Warning Time	4 Short	4 Short	5%
	Duration	3 Long	4 Very Long	5%
TOTAL RISK SCORE		**2.5**	**3.3**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

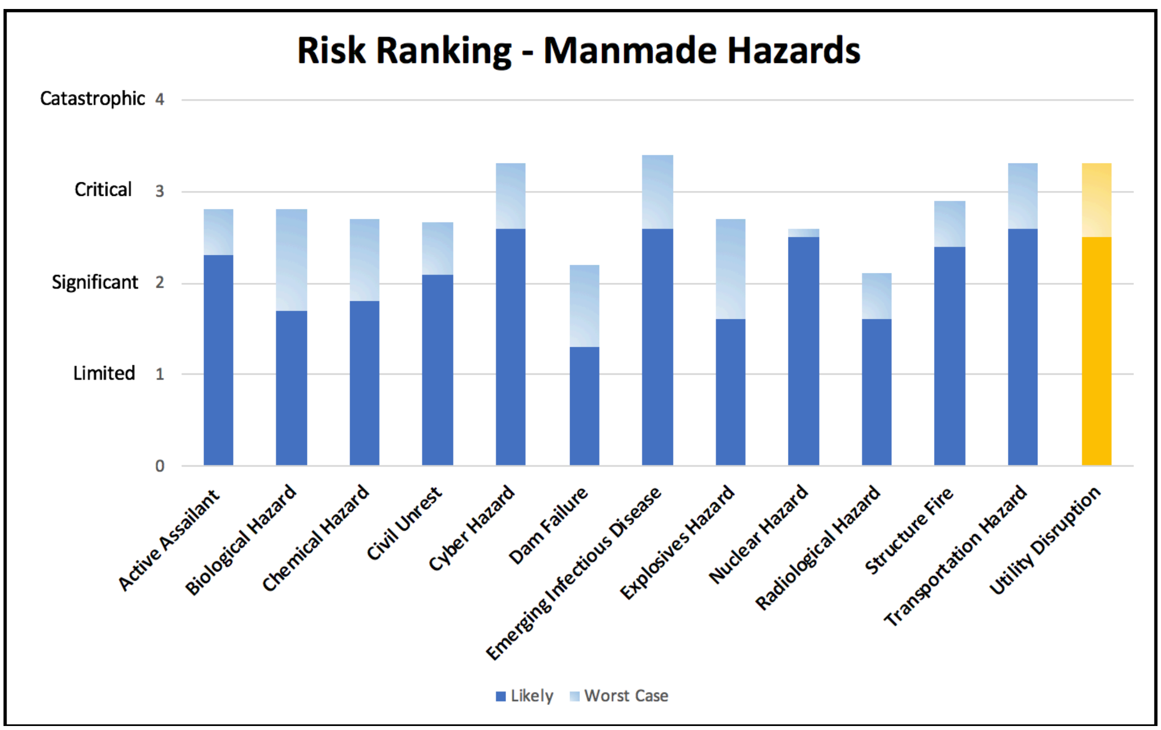
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Utility Disruptions can involve gas lines, water lines, wastewater systems, or electrical infrastructure. The area affected by a Utility Disruption can range from one block to dozens of square miles. It is rare to have any advanced warning of a Utility Disruption, although disruptions may be anticipated prior to extreme weather events. A Utility Disruption can occur nearly anywhere utility infrastructure exists.

The duration of a Utility Disruption depends greatly on the cause of the disruption. Short-term disruptions may only last several minutes and are rarely hazardous. However, long-term Utilities Disruptions can last for several days.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

A Utility Disruption can occur anywhere that relies on electricity, natural gas, water, and sewage systems. All of Howard County is susceptible to the effects of a Utility Disruption.

Utilities infrastructure is especially vulnerable to disruption from extreme weather. Ice storms, snowstorms, tornadoes, hurricanes, flooding, and high winds can lead to the disruption of utility services. Conditions of extreme heat and cold during a Utility Disruption Hazard also greatly increase the likelihood of adverse health effects.

In addition to weather-caused Utility Disruption, disruptions can also result from human error, aging infrastructure, or malfunctioning System Control and Data Acquisition (SCADA) systems.[182]

[182] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

Notable Incidents in Howard County

The majority of Utility Disruptions in Howard County have been the result of extreme weather. There have been 16 Utility Hazard events during the reviewed time period of 2008 to 2019.

2018 March Wind Storm – Howard County experienced strong wind gusts between March 1st and March 3rd. Winds ranged from 55-70 MPH.[183] The power outages resulted in 13 schools within the County being closed that Saturday.[184] Across Maryland, approximately 400,000 outages were caused by high winds in the BGE service area.[185] The number of power outages within the County at 0700 hours March 3rd, 2018 was 14,466.[186] The number of power outages within the County at 1700 hours March 3rd, 2018 was reduced to 10,863.[187]

2012 Hurricane Sandy - A power outage at a water treatment plant resulted in the release of wastewater. Water contamination became a significant threat to health and the environment for those downstream from the plant. Water mains feeding Howard County from the City of Baltimore failed, and the drinking water supply was limited for a period of one to two weeks.

[183] NOAA. Story Map Journal. Retrieved from https://noaa.maps.arcgis.com/apps/MapJournal/index.html?appid=16f7f2279a33467dbdbca54478d9c4c2 (last accessed October 8, 2019).
[184] Janney, E. (2018, March 3). Nearly 11K Without Power In Howard County After Storm. Retrieved from https://patch.com/maryland/columbia/hoco-storm-closures-saturday-march-3-2018 (last accessed October 8, 2019).
[185] BGE News Release, "*BGE Crews Restore Power to More Than 173,000 Customers as Nor'easter Continues to Inflict Damaging High Winds in Central Maryland*" March 2, 2018, (last accessed October 8, 2019).
[186] Howard County Emergency Operations Center Situation Report #3, "HoCo High Winds 3-2-18", March 2, 2018, (last accessed October 8, 2019).
[187] Howard County Emergency Operations Center Situation Report #4, "HoCo High Winds 3-2-18", March 3, 2018, (last accessed October 8, 2019).

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Utility Disruption in Howard County	
Historical Average (time period)	16 events (2008-2018)
Historical Annual Probability	30%+ chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	11-30%+ chance of annual occurrence
Future Likelihood Score	3.37 (Likely- Very Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

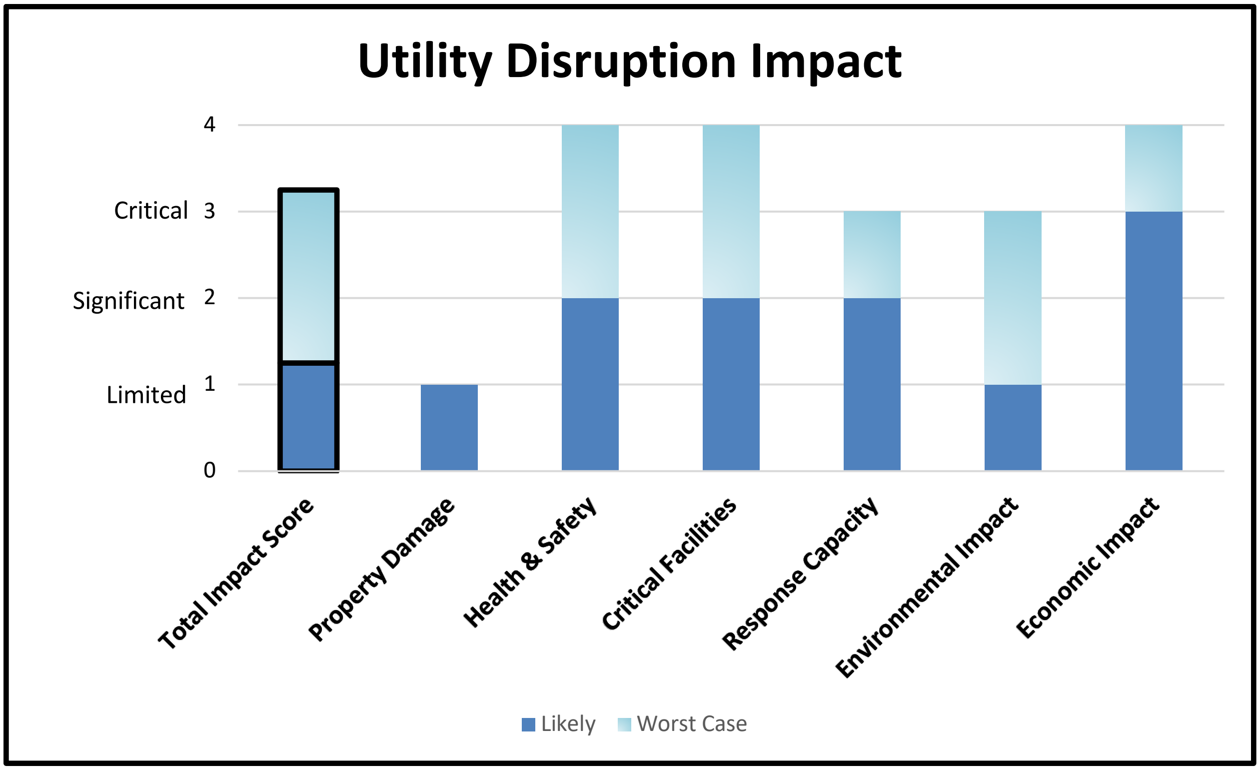
Considerations: The future likelihood of a Utility Disruption in Howard County is not expected to be significantly different from the historical occurrence rate. The future annual probability of the hazard is 11-30%+ chance of annual occurrence, or, one event every 3-9 years. A predicted increase in rainfall levels and extreme storms is expected to result in a slight increase in the likelihood of Utility Disruption Hazard over time.[182,188] Other considerations include aging infrastructure, overgrown trees on power lines, and the high number of utilities within the County.

[188] *Third National Climate Assessment,* U.S. Global Change Research Program (2014). Available at http://nca2014.globalchange.gov/ (last accessed October 9, 2019).

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Utility Disruption Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time prior to the onset of the hazard.	*Short.* No warning time prior to the onset of the hazard.
DURATION	*Long.* It may take up to three days to stabilize the hazard and declare the hazard location safe.	*Very Long.* It may take up to two weeks to stabilize the hazard and declare the hazard location safe.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Utility Disruption Hazard Consequence Analysis Likely		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely. If a Utility Disruption Hazard occurs during cold weather, pipe freezing may cause flood damage to buildings and homes.
HEALTH AND SAFETY	*Significant*	▪ Zero to four deaths likely, although more deaths are expected in extreme weather conditions. ▪ Zero to ten injuries likely. ▪ Deaths and injuries that occur are likely due to heat, extreme weather, or exposure to adverse environmental conditions. Cold weather injuries may result from hypothermia, shock, or severe cardiac arrest. Hot weather injuries may result from hyperthermia, dehydration, heat exhaustion, or severe heat stroke. ▪ Citizens requiring power use for life sustaining interventions would be impacted. For those individuals, underlying medical conditions are the most common causes of death.
CRITICAL FACILITIES	*Significant*	▪ *Utilities* – Seventy-thousand (70,000) people lose power over an area of approximately one-hundred-twenty-five (125 square miles). ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Delays for several days. Widespread traffic control systems outages may cause transportation delays.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Local resources adequate. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Mutual aid needed. Continuity of Operations will not be significantly affected for Howard County fire/rescue. ▪ *Health* – Local resources adequate. Unless the Utility Disruption directly affects the HD, regular services will continue to function. Health Emergency Preparedness functions will be affected due to the emergency response. ▪ *Hospitals* – Local resources adequate. If the hospital is not directly affected by the Utility Disruption, there will be no strain or impact on the hospital. If the hospital is affected, cold-weather power losses have very little impact. Warm-weather power losses (even short-term outages) may result in evacuation for heat concerns. ▪ *Emergency Management* – Local resources adequate. Limited impact to Emergency Management capability.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited. Little to no environmental impact, assuming the Utility Disruption does not cause any accidental industrial or wastewater treatment plant discharges or spills. Less than a day of clean-up or impact to local area.
ECONOMIC IMPACT	*Critical*	▪ Significant loss in economic output. Other costs include cleanup and healthcare for those affected. ▪ Many jobs are lost. ▪ Businesses may be impacted for three days or longer.
TOTAL IMPACT[189]	***Limited-Significant***	▪ **Total Impact Score: 1.25 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[189] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

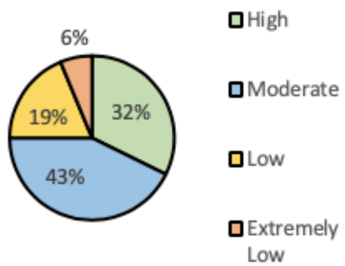
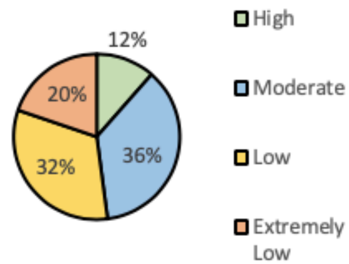
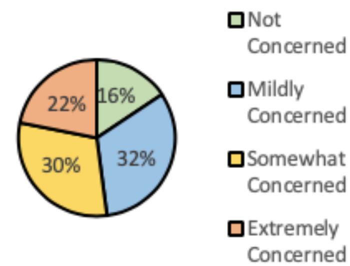
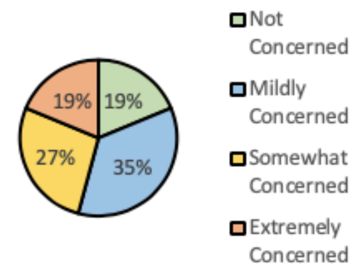
Utility Disruption Hazard Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% damage to critical and non-critical infrastructure. ▪ Anything beyond superficial damage to buildings and structures is unlikely.
HEALTH AND SAFETY	*Catastrophic*	▪ 20 deaths likely, although more deaths are expected in extreme weather conditions. 100-300 injuries likely, although up to 50% of the population may experience minor adverse effects depending on weather conditions. Deaths and injuries that occur are likely due to heat, extreme weather, or exposure to adverse environmental conditions. ▪ Citizens requiring power use for life sustaining interventions would be impacted.
CRITICAL FACILITIES	*Catastrophic*	▪ *Utilities* – Utility loss covers the entire County and surrounding areas. There is no warning time prior to the utility's failures. It takes months to restore all utilities services. Gas stations have also lost power. ▪ *Information/Communications* – There is an impact on information or communications infrastructure. Individual areas may go dark, but generator backup will keep most essential information and communications functions online. However, if the type of failure lasts more than seventy-two (72) hours, generators will be impacted. ▪ *Transportation* – Widespread traffic control systems outages may cause significant transportation delays.
RESPONSE CAPACITY	*Critical*	▪ *Police* – Local resources adequate. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state or federal assistance. Response capability is highly dependent on the availability of generators and fuel. ▪ *Health* – Moderate need for state or federal assistance. Regular HD operations will be significantly altered if a hazard occurs during extreme weather conditions. ▪ *Hospitals* – Moderate need for state or federal assistance. Warm-weather power losses (even short-term outages) may result in evacuation for heat concerns. If water and electricity are completely unavailable, the hospital will not be able to sustain operations. Complete evacuation will be necessary, and all incoming patients will be diverted. ▪ *Emergency Management* – State assistance would be required. Limited impact to Emergency Management capability. A long-lasting hazard may necessitate ongoing Emergency Management support for shelter coordination and economic recovery efforts.
ENVIRONMENTAL IMPACT	*Critical*	▪ Significant. Some loss of species, loss of vegetation, and short-term pollution will occur. Sewage system failures may result in overflows or discharges of untreated sewage that cause water pollution. Localized pollution may be significant if the hazard occurs over an extended period of time and/or if it contaminates the watershed, a regional surface drinking water supply source.
ECONOMIC IMPACT	*Catastrophic*	▪ Billions lost in economic output. Other costs include cleanup and healthcare for those affected. ▪ Thousands of jobs lost and businesses may be impacted for two weeks or longer.
TOTAL IMPACT[190]	***Critical-Catastrophic***	▪ **Total Impact Score: 3.25 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[190] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Utility Disruption Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
			
Average: 3.01 Moderate	*Average: 2.40 Low - Moderate*	*Average: 2.58 Mildly Concerned - Somewhat Concerned*	*Average: 2.46 Mildly Concerned - Somewhat Concerned*

SECTION 8

NATURAL HAZARD PROFILE

Drought

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

According to the National Oceanic and Atmospheric Administration (NOAA), Drought is a complex phenomenon which is difficult to monitor and define. Drought is the *absence* of water. It is a creeping phenomenon that slowly sneaks up and impacts many sectors of the economy and operates on many different time scales. As a result, the climatological community has defined four types of drought: 1) meteorological drought, 2) hydrological drought, 3) agricultural drought, and 4) socioeconomic drought.[191]

Meteorological drought "happens when dry weather patterns dominate an area."[192]

Hydrological drought occurs "when low water supply becomes evident, especially in streams, reservoirs, and groundwater levels, usually after many months of meteorological drought."[193]

Agricultural drought "happens when crops become affected."[194]

Finally, *Socioeconomic* drought "relates the supply and demand of various commodities to drought."[195]

[191] Arndt, and Enloe. Definition of Drought. Retrieved from https://www.ncdc.noaa.gov/monitoring-references/dyk/drought-definition (last accessed September 24, 2019).
[192] Arndt, and Enloe. Definition of Drought. Retrieved from https://www.ncdc.noaa.gov/monitoring-references/dyk/drought-definition (last accessed September 24, 2019).
[193] Arndt, and Enloe. Definition of Drought. Retrieved from https://www.ncdc.noaa.gov/monitoring-references/dyk/drought-definition (last accessed September 24, 2019).
[194] Arndt, and Enloe. Definition of Drought. Retrieved from https://www.ncdc.noaa.gov/monitoring-references/dyk/drought-definition (last accessed September 24, 2019).
[195] Arndt, and Enloe. Definition of Drought. Retrieved from https://www.ncdc.noaa.gov/monitoring-references/dyk/drought-definition (last accessed September 24, 2019).

Risk Profile

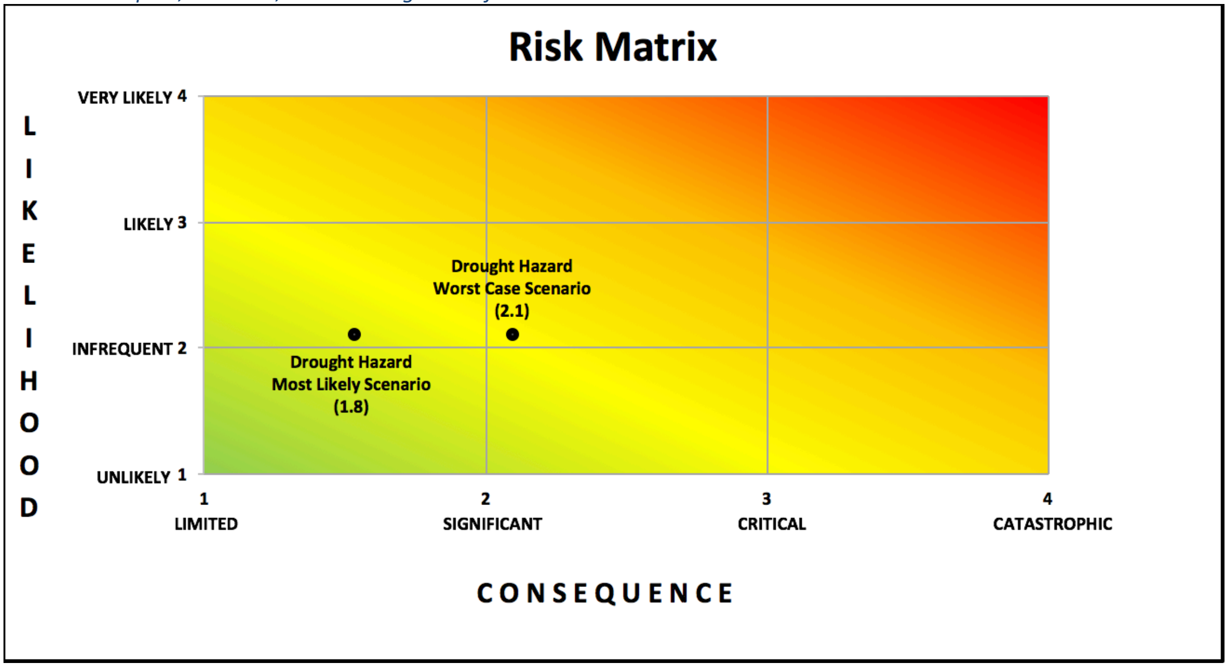
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Drought Risk Profile					
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	2.1 Infrequent-Likely		50%
CONSEQUENCE	**Impact**	1.3 Limited-Significant	2 Significant	40%
	Warning Time	1 Very Long	1 Very Long	5%
	Duration	4 Very Long	4 Very Long	5%
TOTAL RISK SCORE		**1.8**	**2.1**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

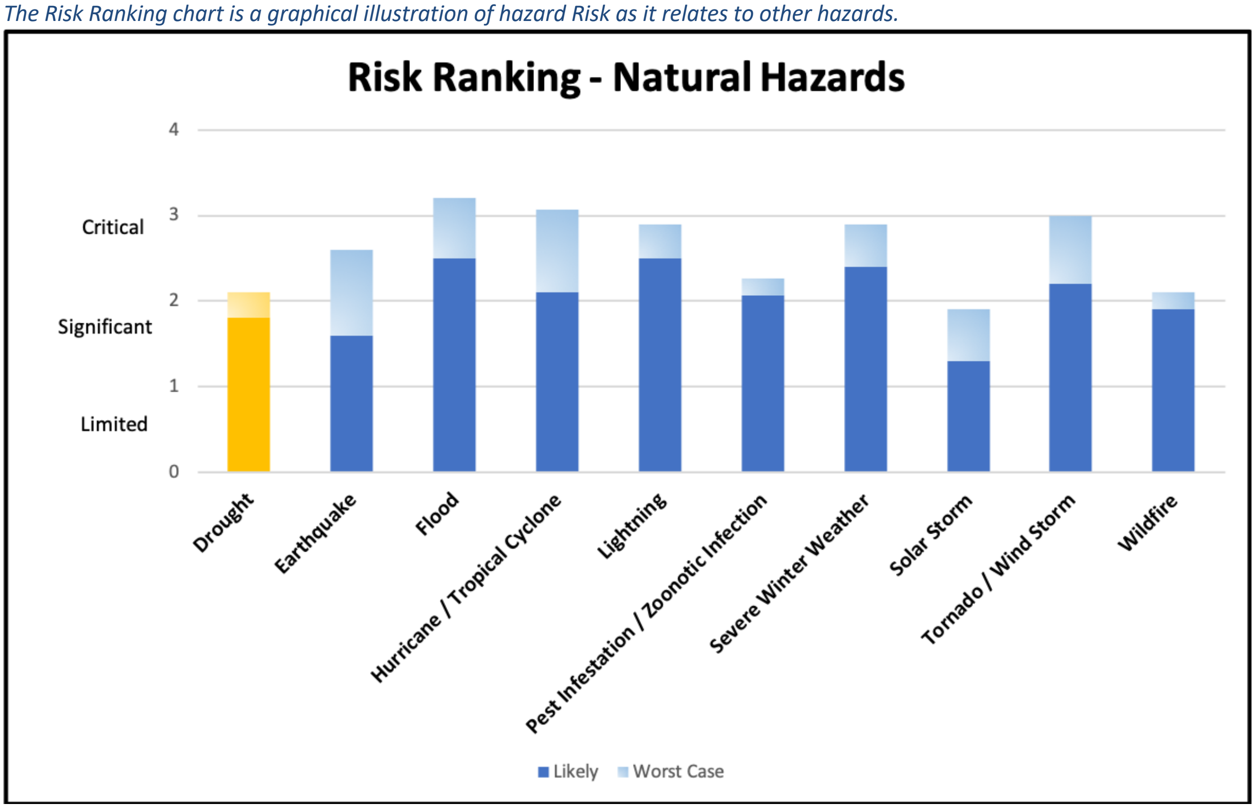
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Droughts usually refer to a period of below-normal rainfall but can also be caused by drying bores or lakes, or anything that reduces the amount of liquid water available. Drought is a recurring feature of nearly all the world's climatic regions.[196]

The U.S. Drought Monitor[197] provides the following drought ratings:

- D0 - Abnormally Dry
  - Short-term dryness slowing planting, growth of crops
  - Some lingering water deficits
  - Pastures or crops not fully recovered
- D1 - Moderate Drought
  - Some damage to crops, pastures
  - Some water shortages developing
  - Voluntary water-use restrictions requested
- D2 - Severe Drought
  - Crop or pasture loss likely
  - Water shortages common
  - Water restrictions imposed
- D3 - Extreme Drought
  - Major crop/pasture losses
  - Widespread water shortages or restrictions
- D4 - Exceptional Drought
  - Exceptional and widespread crop/pasture losses
  - Shortages of water creating water emergencies

[196] For additional information about droughts, visit the National Integrated Drought Information System (NIDIS), www.drought.gov (last accessed September 24, 2019).
[197] The U.S. Drought Monitor . (2019, September 23). Retrieved from https://www.drought.gov/drought/ (last accessed September 24, 2019).

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Droughts may occur anywhere in the United States. Different regions may be affected by drought conditions differently, depending on normal meteorological conditions (such as precipitation and temperature) and geological conditions (such as soil type and subsurface water levels).

Drought is possible throughout the planning area, and in the Central Maryland region in general. As there is no defined geographic boundary for this hazard, all properties within Howard County are exposed equally to the risk of drought. The probability of a drought occurring in any specific region depends on atmospheric and climatic conditions.

Duration and frequency can be used as indicators of potential severity. Variation in drought risks to people and property cannot be distinguished by area. The hazard has a uniform probability of occurrence across the entire County.

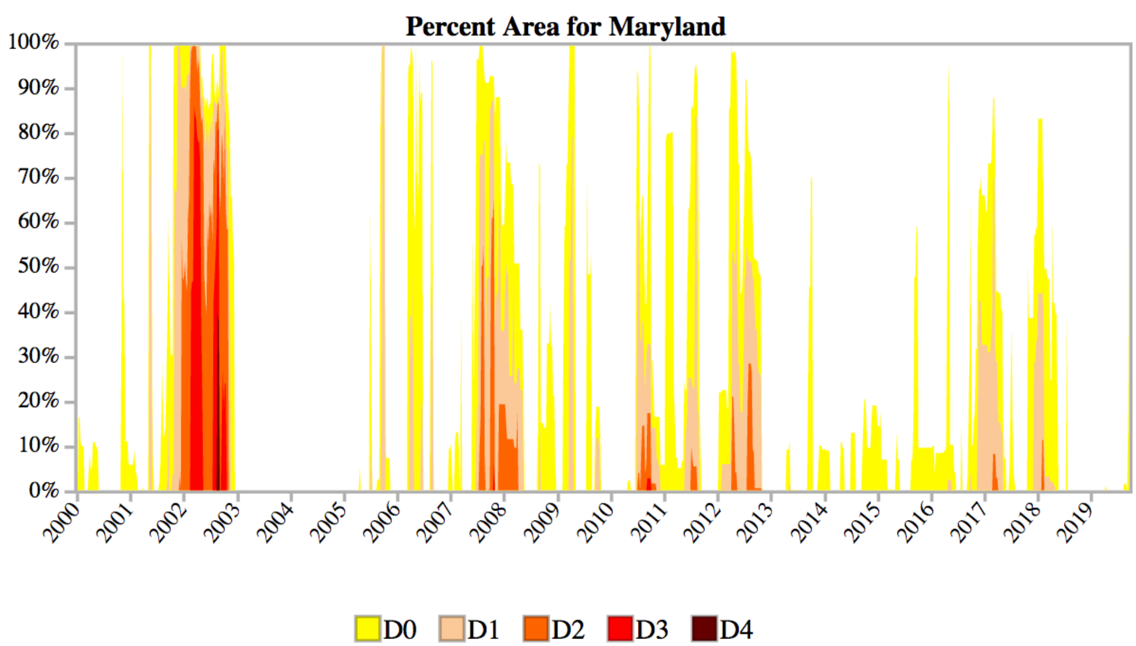
III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

According to the National Climatic Data Center (NCDC) database, Howard County has experienced 13 drought events from 1950 to 2019. All 13 events occurred between 1995 and 2007. The database provides no indication as to why no events were listed prior to 1995, although presumably occurrences followed the same pattern and frequency as shown in the NCDC list. The database does not show any drought events occurring in Howard County since 2007.[198] According to U.S. Drought Portal "since 2000, the longest duration of drought (D1-D4) in Maryland lasted 48 weeks beginning on June 7th, 2016 and ending on May 2nd, 2017. The most intense period of drought occurred the week of October 4th, 2016 where D4 affected 52.13% of Maryland land."[199]



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[198] NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(Z)+DroughtandbeginDate_mm=01andbeginDate_dd=01andbeginDate_yyyy=2007andendDate_mm=06andendDate_dd=30andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 10, 2019).

[199] Drought in Maryland. (2019, June 20). Retrieved from https://www.drought.gov/drought/states/maryland?places=Howard County, MD, USA (last accessed October 10, 2019).

[200] The chart lists all the Droughts in Maryland since 2000. Specifically, "The U.S. Drought Monitor started in 2000. Since 2000, the longest duration of drought (D1-D4) in Maryland lasted 48 weeks beginning on June 07, 2016 and ending on May 2, 2017. The most intense period of drought occurred the week of October 4, 2016 where D4 affected 52.13% of Maryland land." Citation: U.S. Drought Portal. (2019, September 20). Drought in Maryland. Retrieved from https://www.drought.gov/drought/states/maryland?places=Howard+County,+MD,+USA (last accessed September 24, 2019).

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

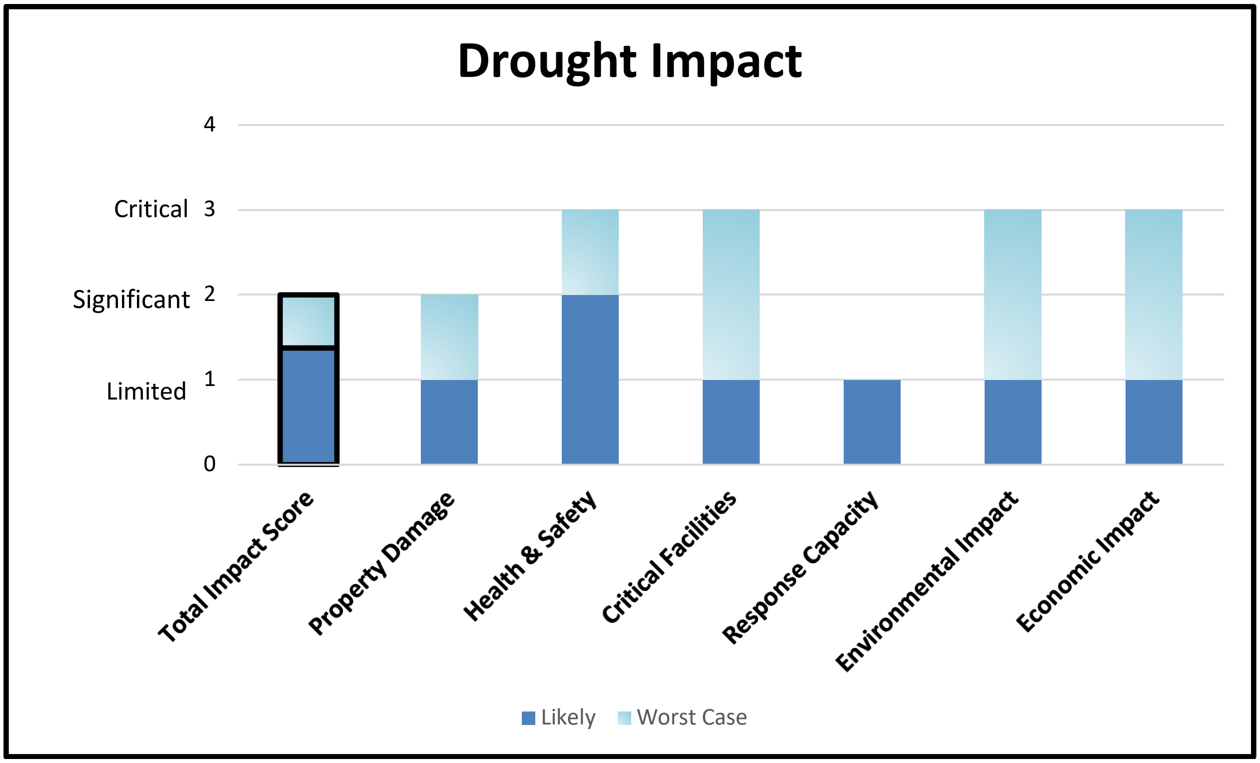
Future Likelihood of a Drought in Howard County	
Historical Average (time period)	13 events (1995-2019)
Historical Annual Probability	30+% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	1-10% chance of annual occurrence
Future Likelihood Score[73]	2.125 (Infrequent)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: Other considerations including climate change increase the likelihood of this hazard occurring in Howard County. The future annual probability of a drought is 1-10% chance of annual occurrence, or, one event every 10-99 years.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Drought Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Very long.* Three to five weeks.	*Very long.* Three to five weeks.
DURATION	*Very Long.* Four weeks to several months.	*Very Long.* Two to five months.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Drought Consequence Analysis **Likely**		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% of critical and non-critical infrastructure damage if water service is uninterrupted. ▪ Damaged landscaping is expected and farmers experience crop pasture loss.
HEALTH AND SAFETY	*Significant*	▪ Zero to five injuries are expected. Dehydration, heat exhaustion, and heat stroke are the most common causes of injuries.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – No facility shut down or out of service is expected. Voluntary restrictions may be imposed. ▪ *Information/Communications* – No shutdown. No major impact on information or communications infrastructure. ▪ *Transportation* – No delays or shutdowns expected.
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. Minimal impact to response capability by law enforcement. ▪ *Fire and Rescue* – Local resources adequate. Limited impact on the response capability, primarily to allow rehabilitation for crews working extended operations. ▪ *Health* – Local resources adequate. HD operations will not be affected and will monitor the extreme heat incident from the Health Department Operations Center (HDOC).
ENVIRONMENTAL IMPACT	*Limited*	▪ Temporary spike in air pollution with minimal effect on water and land resources is expected.
ECONOMIC IMPACT	*Limited*	▪ Limited economic consequences. Probable shift in hours of construction projects and other outdoor projects. ▪ Farmers within the County experience crop pasture loss which may result in higher prices for produce.
TOTAL IMPACT[201]	***Limited-Significant***	▪ **Total Impact Score: 1.375 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[201] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

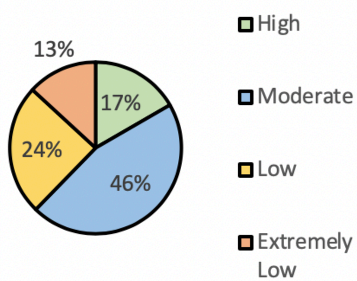
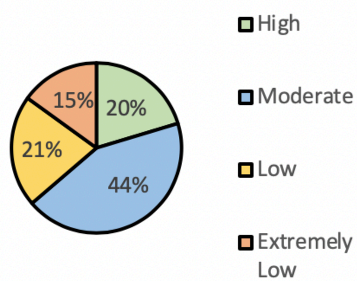
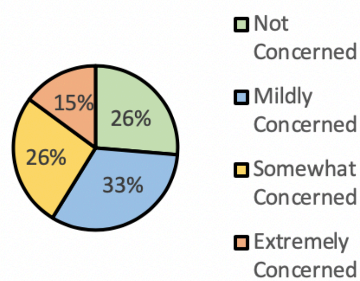
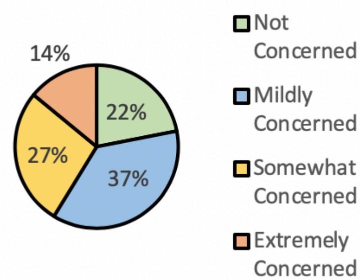
The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

Drought Consequence Analysis Worst-Case				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Significant*	▪ Critical and non-critical infrastructure will be damaged. ▪ Damaged well pumps, landscaping, forests, and occasional fires are expected.		
HEALTH AND SAFETY	*Critical*	▪ Five deaths are expected. Heat stroke is the most common cause of death. ▪ 0-20 injuries are expected. Dehydration, heat exhaustion, and heat stroke are the most common causes of injuries.		
CRITICAL FACILITIES	*Critical*	▪ *Utilities* – Mandatory water restrictions are imposed and there are water shortages, creating possible water emergencies. ▪ *Information/Communications* – No shutdown. No major impact on information or communications infrastructure. ▪ *Transportation* – No delays or shutdowns expected.		
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. ▪ *Fire and Rescue* – Mutual aid needed. Water supply contingencies may need to be out in place for suppression efforts and water bans for stations may be used. ▪ *Health* – Local resources adequate. HD operations will not be affected and will monitor the extreme heat incident from the HDOC.		
ENVIRONMENTAL IMPACT	*Critical*	▪ Would cause increased air (ozone) and water pollution, drinking water reservoir would drop. Quality in the large reservoir systems would be affected. ▪ The decline in water tables would affect stream levels to drop or dry up impacting aquatic and terrestrial life, including livestock, and may cause a loss of individuals, but not cause extinction. ▪ Death among livestock and wildlife. ▪ If drought/heat is broken by heavy rains, this will cause an additional spike in water pollution and flooding.		
ECONOMIC IMPACT	*Critical*	▪ Serious economic impact, especially among the agriculture community.		
TOTAL IMPACT[202]	***Significant***	▪ **Total Impact Score: 2 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

[202] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Drought Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
 *Average: 2.66* *Low - Moderate*	 *Average: 2.69* *Low - Moderate*	 *Average: 2.30* *Mildly Concerned - Somewhat Concerned*	 *Average: 2.33* *Mildly Concerned - Somewhat Concerned*

Earthquake

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

An Earthquake is a sudden release of energy from the earth's crust that creates seismic waves. Stress is created in the earth's crust from thermal variations, tectonic changes, and other forms of pressure. Weaknesses in the earth crust yield when the stresses exceed the friction along these crustal weaknesses, and an earthquake happens. At the earth's surface, earthquakes may manifest themselves by a shaking or displacement of the ground.

Risk Profile

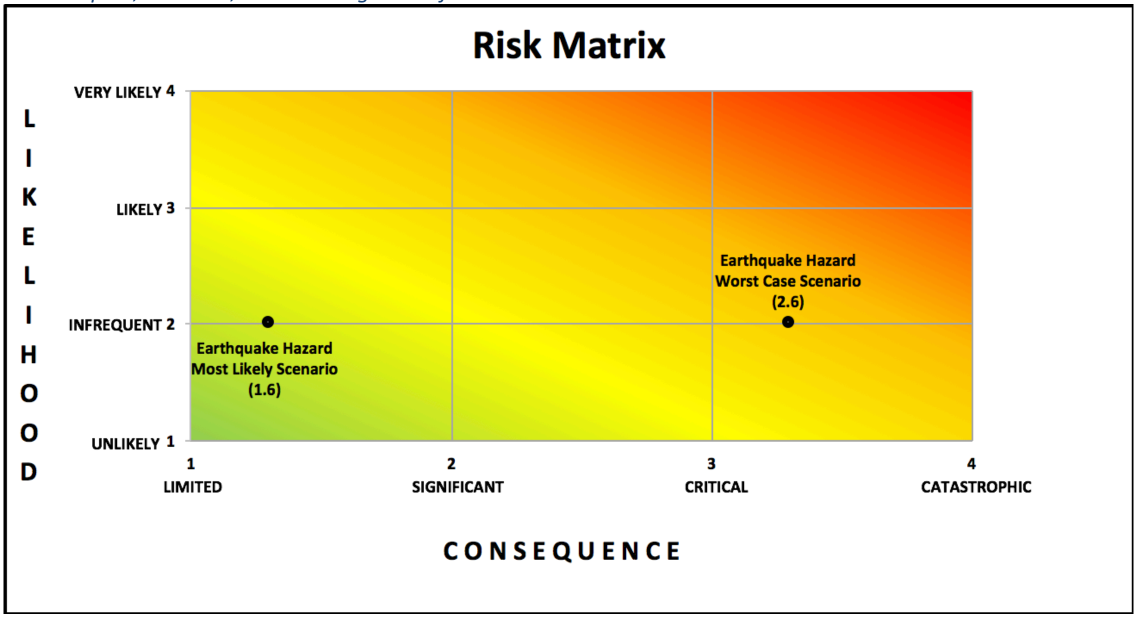
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Earthquake Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	2 Infrequent		50%
CONSEQUENCE	**Impact**	1 Limited	3.6 Critical-Catastrophic	40%
	Warning Time	4 Short	4 Short	5%
	Duration	1 Short	1 Short	5%
TOTAL RISK SCORE		**1.6**	**2.6**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

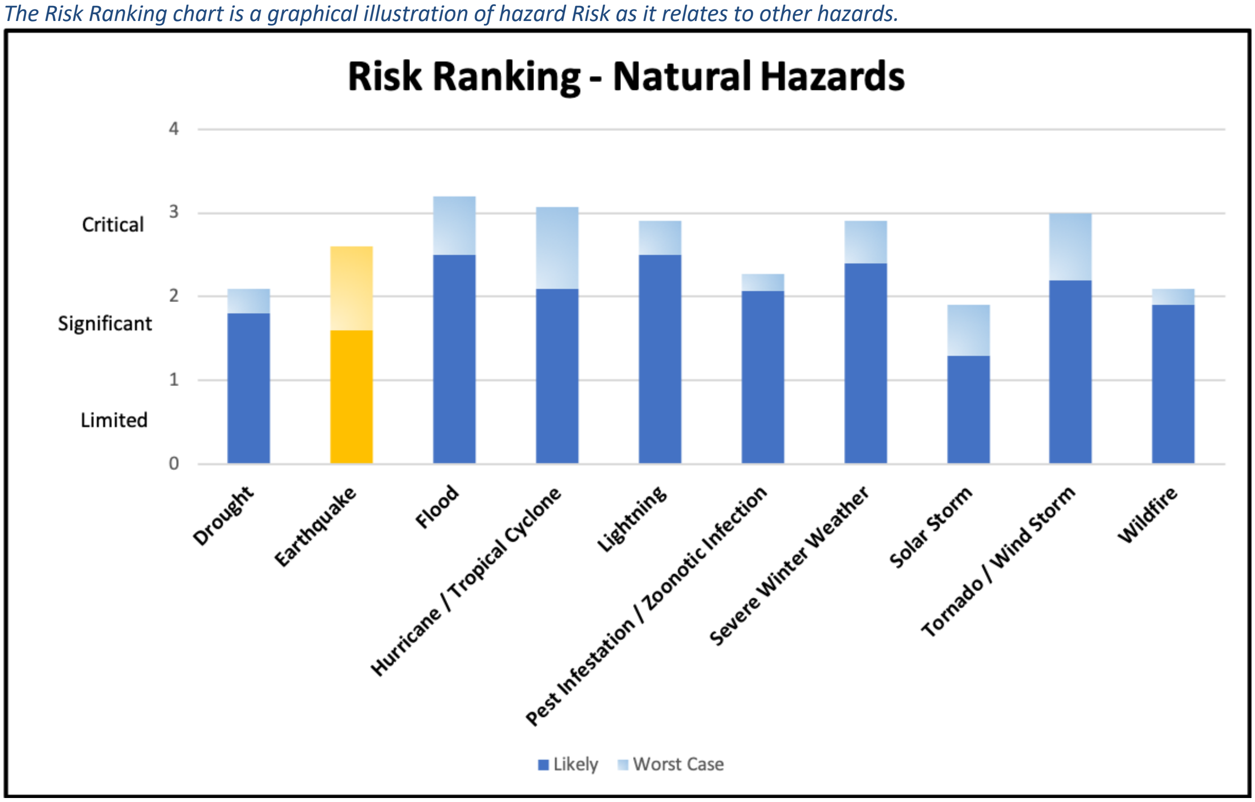
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

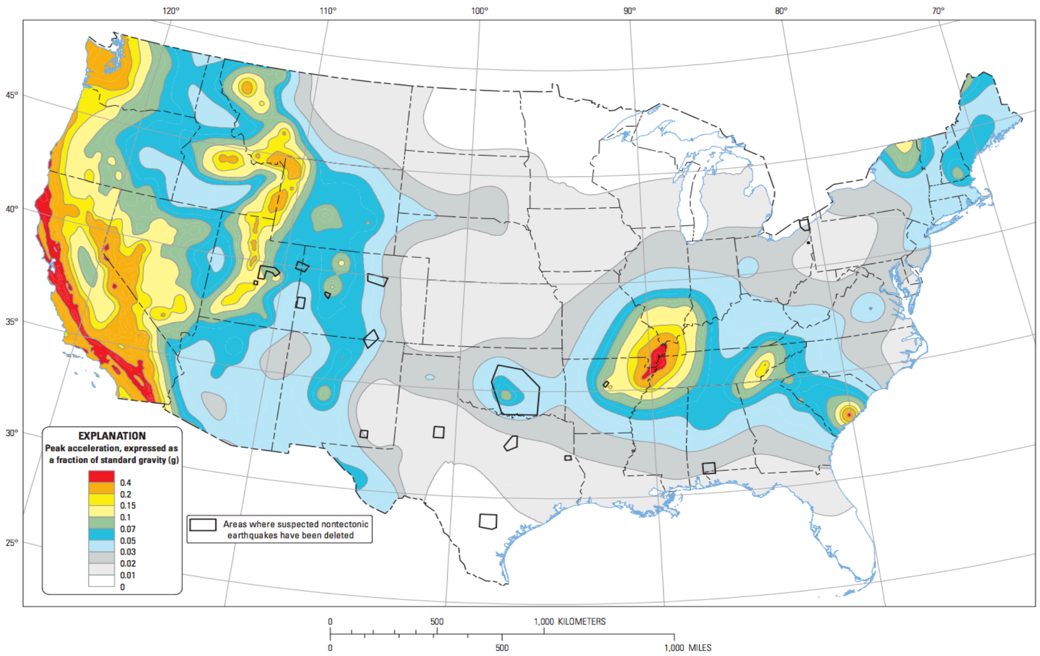
An Earthquake is a sudden release of energy from the earth's crust that creates seismic waves. Tectonic plates become stuck, thus putting a strain on the ground. When the strain becomes so great that rocks give way, fault lines occur. At the Earth's surface, earthquakes may manifest themselves by a shaking or displacement of the ground. This may lead to loss of life and destruction of property. The size of an earthquake is expressed quantitatively as magnitude[203], while local strength of shaking is expressed as intensity.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

The entire County is susceptible to the effects of earthquakes. The map shown below was produced by the 2014 U.S. Geological Survey National Seismic Hazard Mapping Project. "The National Seismic Hazard Maps are derived from seismic hazard curves calculated on a grid of sites across the United States that describe the annual frequency of exceeding a set of ground motions."[204]

[203] The inherent size of an earthquake is commonly expressed using a magnitude.
[204] United States - Lower 48. Retrieved from https://earthquake.usgs.gov/hazards/hazmaps/conterminous/ (last accessed September 24, 2019).



Ten-percent probability of exceedance in 50 years map of peak ground acceleration [205]

According to the USGS, there were four notable earthquake incidents in Maryland since 2014[206]:

- M 1.6 - 8km WNW of Wilson-Conococheague, Maryland
    - Time: 2019-01-17 04:26:55 (UTC)
    - Location: 39.675°N 77.932°W
    - Depth: 5.0 km
- M 1.9 - 4km NW of Riva, Maryland
    - Time: 2015-08-09 02:07:06 (UTC)
    - Location:38.980°N 76.663°W
    - Depth: 7.0 km
- M 1.5 - 12km SW of Sykesville, Maryland
    - Time: 2017-10-30 00:34:30 (UTC)
    - Location: 39.279°N 77.051°W
    - Depth: 2.0 km
- M 1.5 - 11km NW of Highland, Maryland
    - Time: 2017-11-11 15:55:43 (UTC)
    - Location: 39.261°N 77.039°W
    - Depth: 4.0 km

[205] The data and maps shown are produced by the 2014 U.S. Geological Survey National Seismic Hazard Mapping Project. "The National Seismic Hazard Maps are derived from seismic hazard curves calculated on a grid of sites across the United States that describe the annual frequency of exceeding a set of ground motions." Citation: United States - Lower 48. Retrieved from https://earthquake.usgs.gov/hazards/hazmaps/conterminous/ (last accessed September 24, 2019). See also: : United States - Lower 48. Retrieved from https://earthquake.usgs.gov/static/lfs/nshm/conterminous/2014/2014pga2pct.pdf (last accessed December 16, 2019).

[206] Search Earthquake Catalog. Retrieved from https://earthquake.usgs.gov/earthquakes/search/ (last accessed September 24, 2019).

Howard County has a particular vulnerability to Earthquakes for several reasons. Most buildings in the County are not built to Earthquake-Resistant Requirements. Also, because earthquakes have historically happened so infrequently in the area, most residents are not as familiar with what to do during an earthquake. The County also has a high prevalence of nursing homes, which could present additional earthquake vulnerabilities for citizens with access and/or functional needs.

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

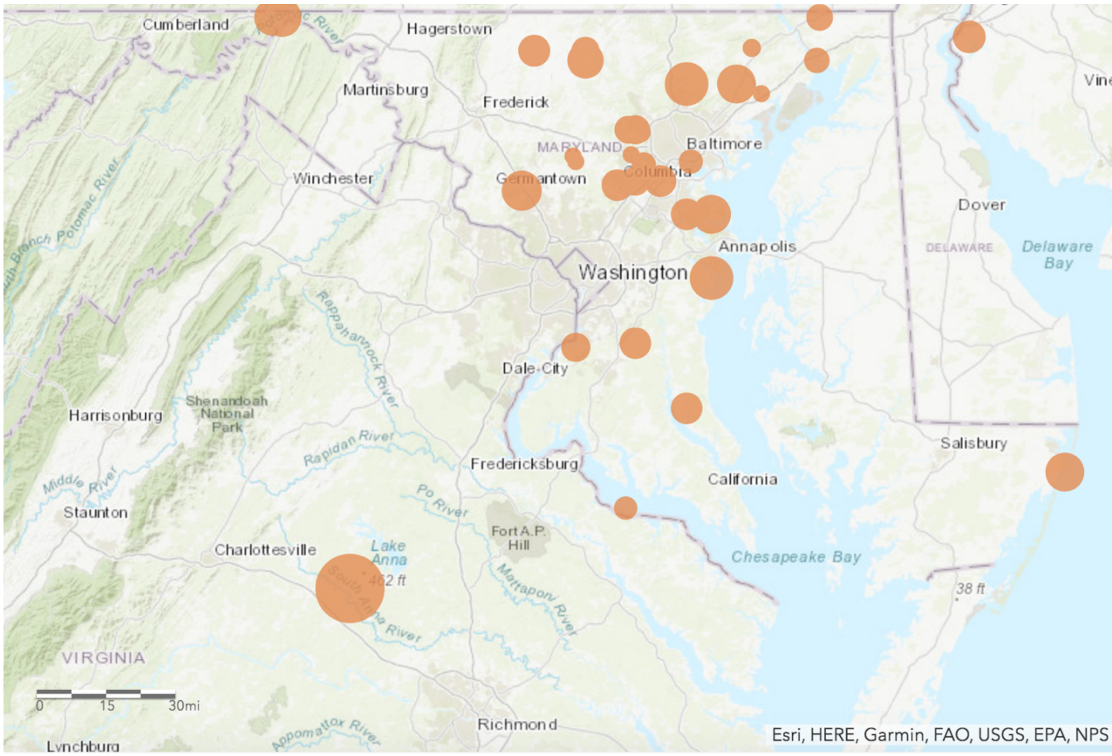
The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

Data from the Maryland Geological Survey (MGS), indicates there have been 70 earthquakes with epicenters in Maryland between 1758-2017.[207] The USGS shows the earliest recorded earthquake with its epicenter in Maryland occurred in Annapolis on April 24th, 1758. The shock lasted 30 seconds and could be felt as far away as Pennsylvania. In recent years, moderate-sized earthquakes which occurred in nearby states have been felt in Maryland with only minimal effects. On November 19th, 1969, a 4.3 magnitude earthquake near Elgood, West Virginia was felt in Central Maryland, including Howard County. On February 28th, 1973, residents throughout the Mid-Atlantic region were jolted awake by shock waves from a minor earthquake near the Delaware/New Jersey/Pennsylvania border. Numerous points in Northeastern Maryland reported this earthquake.[208]

Approximate Epicenter of Maryland Earthquakes since 1758

[207] These numbers reflect the most up to date data according to the Maryland Geological Survey. Events that may have occurred in 2018 and 2019 are not listed. Citation: Maryland Geological Survey. Earthquakes and Maryland. Retrieved from http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html (last accessed December 16, 2019).

[208] See Earthquakes and Maryland, http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html (last accessed September 24, 2019).



(Source: Maryland Geological Survey)[209]

Maryland's USGS earthquake history was reviewed to identify past earthquake occurrences that have impacted Howard County. Historically, there have been two recorded earthquakes with an epicenter in Howard County. Additionally, there was a cluster of small earthquakes in 1993 in Allview Estates in Columbia, MD[210]. In 2017, Howard County experienced two earthquakes. The first was an earthquake of 1.52 magnitude in Glenelg, Maryland. The second was an earthquake of 1.5 magnitude in Roxbury, Maryland.[211] Including the recent earthquake data provided by the MGS, there has been 12 earthquake events in Howard County within the reviewed time period of 1990-2019. The likelihood of significant earthquake damage in Howard County is low since the probability of the area being stricken by an earthquake is relatively low as compared to other parts of the country. Even though earthquakes do occur occasionally, the County is located in an area of very low seismic activity.

Notable Incidents Within Howard County

November 19th, 1969

On November 19th, 1969, a 4.3 magnitude earthquake near Elgood, West Virginia was felt in Central Maryland, including Howard County.[212]

[209] Maryland Geological Survey. Earthquakes and Maryland. Retrieved from http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html (last accessed September 24, 2019).
[210] See Earthquakes and Maryland, http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html (last accessed September 24, 2019).
[211] Maryland Geological Survey. (n.d.). Earthquakes and Maryland. Retrieved from http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html (last accessed October 10, 2019).
[212] Southern California Earthquake Center. The Great SouthEast ShakeOut. Retrieved from https://www.shakeout.org/southeast/maryland/.

March - November 1993

From March through December 1993, data indicated that a series of two-dozen small tremors occurred near Columbia, Maryland, ranging in magnitude from >1 to 2.7 on the Richter Scale.[213]

August 23rd, 2011

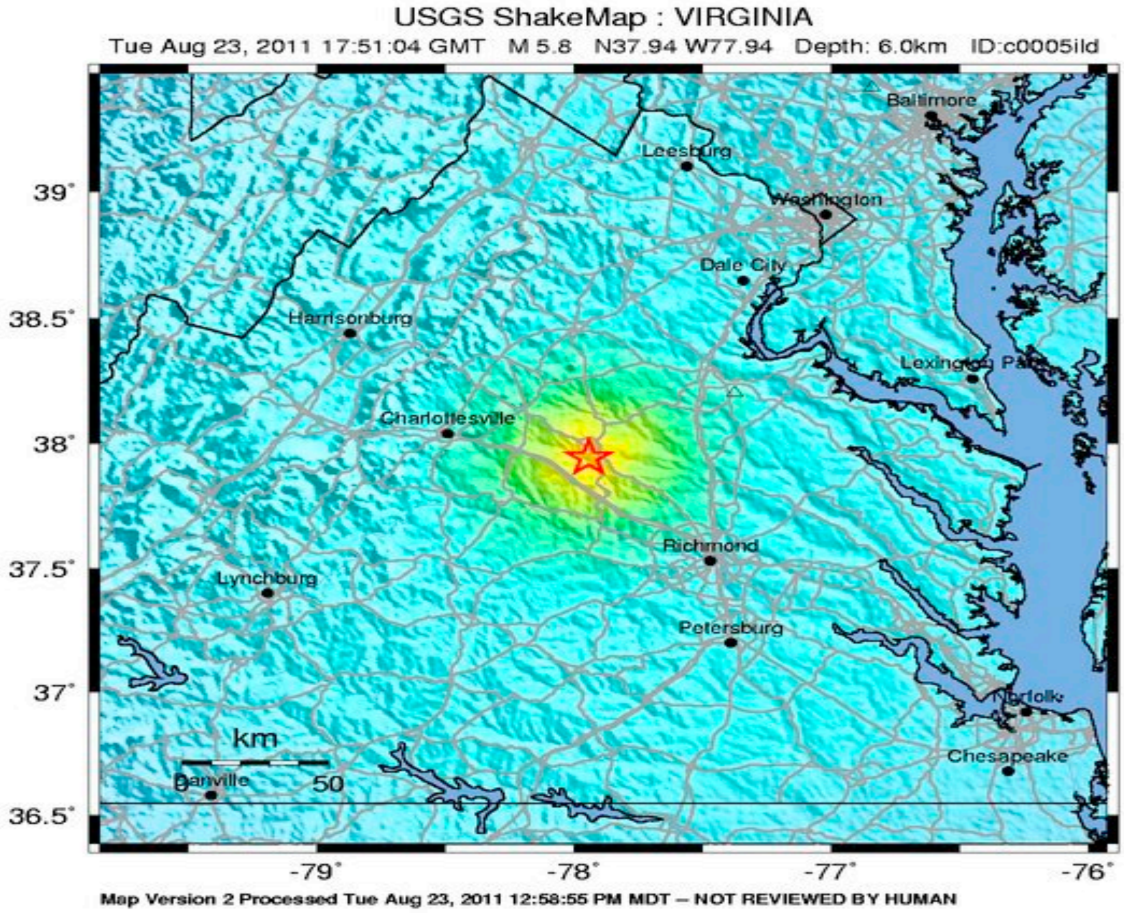
On August 23rd, 2011, Maryland experienced the effects of a nearby earthquake when a 5.8 magnitude quake centered in Virginia impacted much of the East Coast. Tremors were felt as far south as North Carolina, as far north as Buffalo and Boston, and as far west as Detroit. The epicenter of the earthquake was about 3.5 miles beneath Mineral, Virginia, which is 35 miles northwest of Richmond. The USGS indicated the earthquake was one of the strongest ever to occur in Virginia and the strongest felt in Maryland. After the ground shook for several seconds, buildings were evacuated, and some businesses and agencies shut down for the afternoon. Rail travel was interrupted, and many commuters faced an early, congested rush hour.[214] Damage inspections after the earthquake found structural damage was limited, although in some areas there were significant localized damages. In Howard County, many residents were startled by the earthquake but there was no significant damage or injuries reported.[215]
The figure below is a USGS "shake map" that shows the intensity of shaking from the Mineral, Virginia earthquake. Note that the area west of Baltimore, where Howard County is located, experienced weak to low shaking intensity and no expected damages.

USGS Shake Map for the Mineral, Virginia Earthquake of 2011

[213] Maryland Geological Survey. Earthquakes and Maryland. Retrieved from http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html.

[214] Calvert, Scott and Childs Walker, *Earthquake in Virginia Rattles Baltimore and the East Coast*, Baltimore Sun, August 23, 2011, available at http://articles.baltimoresun.com/2011-08-23/news/bs-md-earthquake-20110823_1_maryland-geological-survey-earthquake-smaller-temblors (last accessed October 10, 2019).

[215] Howard County Administration, *Howard County Earthquake Update*, August 23, 2011.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

October 30th, 2017

An earthquake with a magnitude of 1.52 occurred in Glenelg, Maryland.[216]

November 11th, 2017

An earthquake with a magnitude of 1.5 occurred in Roxbury, Maryland.[217]

Future Likelihood of the Hazard for Howard County

[216] Maryland Geological Survey. Earthquakes and Maryland. Retrieved from http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html (last accessed December 16, 2019).

[217] Maryland Geological Survey. Earthquakes and Maryland. Retrieved from http://www.mgs.md.gov/geology/geohazards/earthquakes_and_maryland.html.

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of an Earthquake in Howard County	
Historical Average (time period)	12 events (1990-2019)
Historical Annual Probability	30% + chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	1-10% chance of annual occurrence
Future Likelihood Score[73]	2 (Infrequent)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

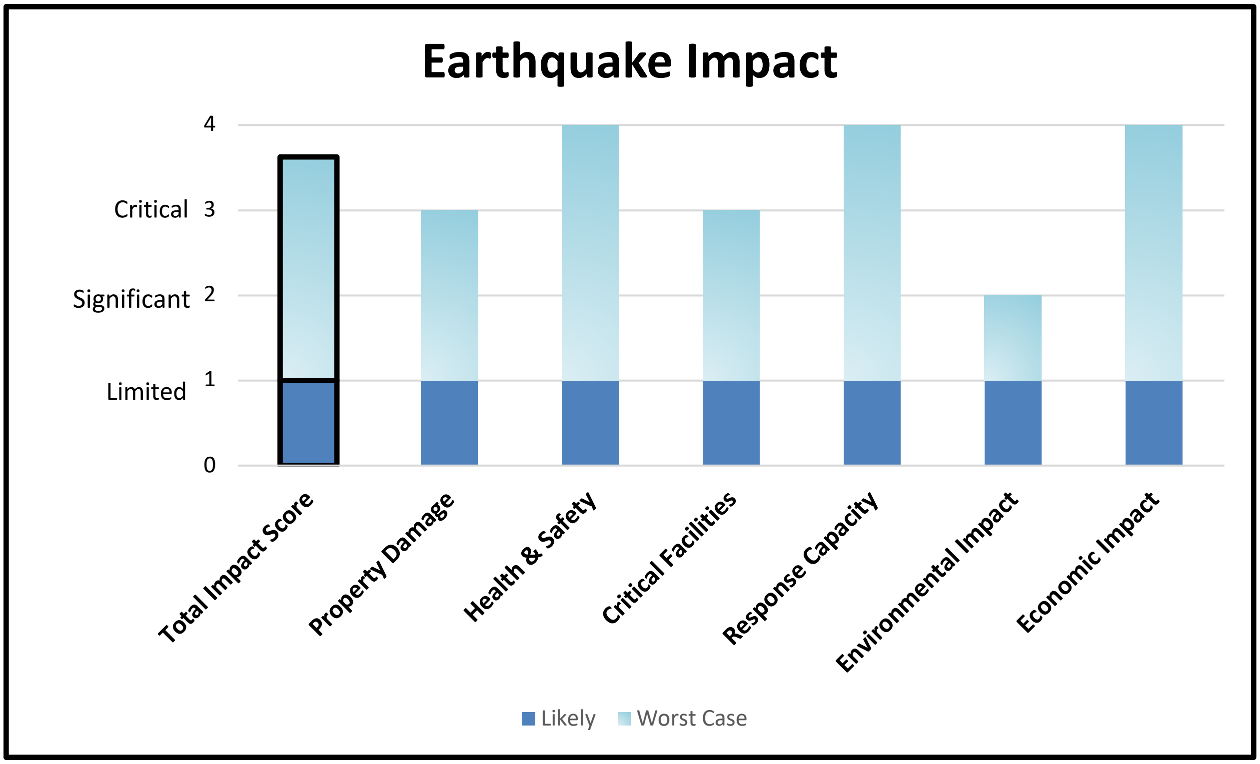
Considerations: While there is a very likely chance (30%+) of *any* earthquake occurring annually based on historical data, most earthquakes would be low enough in intensity that most residents would not feel them. The historical number of earthquakes therefore is higher than the future likelihood of the hazard occurring. The future annual probability of an Earthquake Hazard is 1-10% chance of annual occurrence, or one event every 10-99 years. One consideration that could impact the future likelihood of the hazard occurring is if there is an increase in fracking[218] within the County.

[218] Fracking is defined as "Hydraulic fracturing (informally known as hydrofracking, fracking, fracing, or hydrofracturing) is a process that typically involves injecting water, sand, and chemicals under high pressure into a bedrock formation via a well. This process is intended to create new fractures in the rock as well as increase the size, extent, and connectivity of existing fractures in order to extract trapped oil and gas." (Citation: USGS. Hydraulic Fracturing. Retrieved from https://www.usgs.gov/mission-areas/water-resources/science/hydraulic-fracturing?qt-science_center_objects=0#qt-science_center_objects, last accessed December 29, 2019.)

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Earthquake Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time.	*Short.* No warning time.
DURATION	*Short.* 15 seconds.	*Short.* Two minutes.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Earthquake Consequence Analysis Likely				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Limited*	▪ Critical and non-critical infrastructure are not damaged. ▪ No structural damage expected.		
HEALTH AND SAFETY	*Limited*	▪ *Health*- Zero deaths are expected. Being crushed by structural damage is the most common cause of death. ▪ *Health*- Zero to five injuries are expected. Broken or fractured bones and internal bleeding are the most common causes of injuries.		
CRITICAL FACILITIES	*Limited*	▪ Utilities – Water lines would be the only essential functions that will be out of service. Other outages unlikely. ▪ *Information/Communications* – No shutdown. No major impact on information or communications infrastructure. ▪ *Transportation* –Impacts if any to transportation will be minor and short-term.		
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. ▪ *Fire and Rescue* – Local resources adequate. Should not impact operations. May require damage assessment teams. ▪ *Health* – Local resources adequate. HD operations will not be affected after building has been cleared to be safe by emergency/ facility personnel. ▪ *Public Works* – Local resources adequate with no impact response capability and continuity of operations.		
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal environmental impact on air, water, and land is expected. ▪ Limited environmental impact is expected.		
ECONOMIC IMPACT	*Limited*	▪ Limited economic impact.		
TOTAL IMPACT[219]	***Limited***	▪ **Total Impact Score: 1 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

[219] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

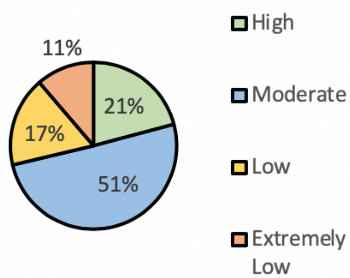
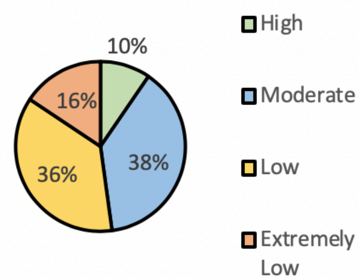
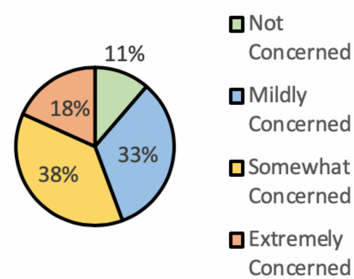
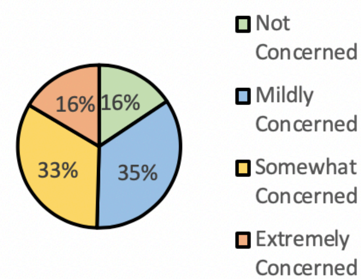
Earthquake Consequence Analysis **Worst-Case**		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Critical*	▪ Most critical and non-critical infrastructure will be damaged. ▪ Chimney collapses on homes, objects on walls and shelves fall and topple, historic building collapse, oil and gas pipeline shutdowns and inspections, hospital operating room shutdowns, elevator shutdowns, garage doors inoperable due to frame shifting. Hardened structure shifting, foundation shifting and damage, infrastructure cracks and damage causing gas and water leaks, damage to bridges and overpasses.
HEALTH AND SAFETY	*Catastrophic*	▪ Minimal deaths are expected. Being crushed by structural damage are the most common causes of death. ▪ 100-200 injuries are expected. Broken or fractured bones and internal bleeding are the most common causes of injuries.
CRITICAL FACILITIES	*Critical*	▪ *Transportation* – Transportation, water service, wastewater, landfill, transfer station, and fire stations will be out of service. ▪ *Information/Communications* – Significant/extended outage expected. ▪ *Utilities* – Hardened structure shifting, foundation shifting and damage, infrastructure cracks and damage causing gas and water leaks and limited power loss.
RESPONSE CAPACITY	*Catastrophic*	▪ *Police* – Moderate need for state or Federal assistance. Moderate impact on law enforcement due to security detail, traffic detail, and increased response to hazard calls. Additional resources required from Sherriff's office and possible State police. ▪ *Fire and Rescue* – Severe and long-lasting need for state or federal assistance. Significant impact to response capability, alternate work schedules may be required, USandR, DMAT, maybe DMORT. COOP Plans will be needed. ▪ *Health* – Moderate need for state or federal assistance. HD has COOP plans in place to ensure essential functions continue either on site (if possible) or at an alternate location. ▪ *Public Works* – Moderate to significant and long-lasting need for state or Federal assistance with severe impact to response capability and continuity of operations.
ENVIRONMENTAL IMPACT	*Significant*	▪ Minimal direct impact on air, water, and land resources. May cause a loss of individual animals and plants. ▪ Infrastructure damage can cause air, water, or land pollution if it disrupts facilities such as pipelines carrying hazardous materials industrial manufacturing plants, or sewage treatment plants. ▪ Limited-Significant environmental impact is expected.
ECONOMIC IMPACT	*Catastrophic*	▪ Hundreds of millions and up of loss in dollar value. ▪ Business, government, and retail closures and residential dislocation with a minimum of one to two-week evaluations before recovery begin in economic consequences.
TOTAL IMPACT[220]	***Critical-Catastrophic***	▪ **Total Impact Score: 3.625 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[220] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Earthquake Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
 *Average: 2.81* *Low - Moderate*	 *Average: 2.42* *Low - Moderate*	 *Average: 2.63* *Mildly Concerned - Somewhat Concerned*	 *Average: 2.50* *Mildly Concerned - Somewhat Concerned*

Flood

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

A Flood is defined as an accumulation of water that exceeds a physical barrier or collects in a low-lying area that leads to the inundation of an area. Flooding typically results from large scale weather systems that generate prolonged or highly impactful rainfall. Other conditions such as winter snow thaws, over-saturated soil, ice jams breaking apart, and urbanization can cause flooding as well. Howard County can be impacted by several types of flooding including, Riverine flooding and Urban flooding. Descriptions of these types of floods are explained below in the description on the hazard.

Risk Profile

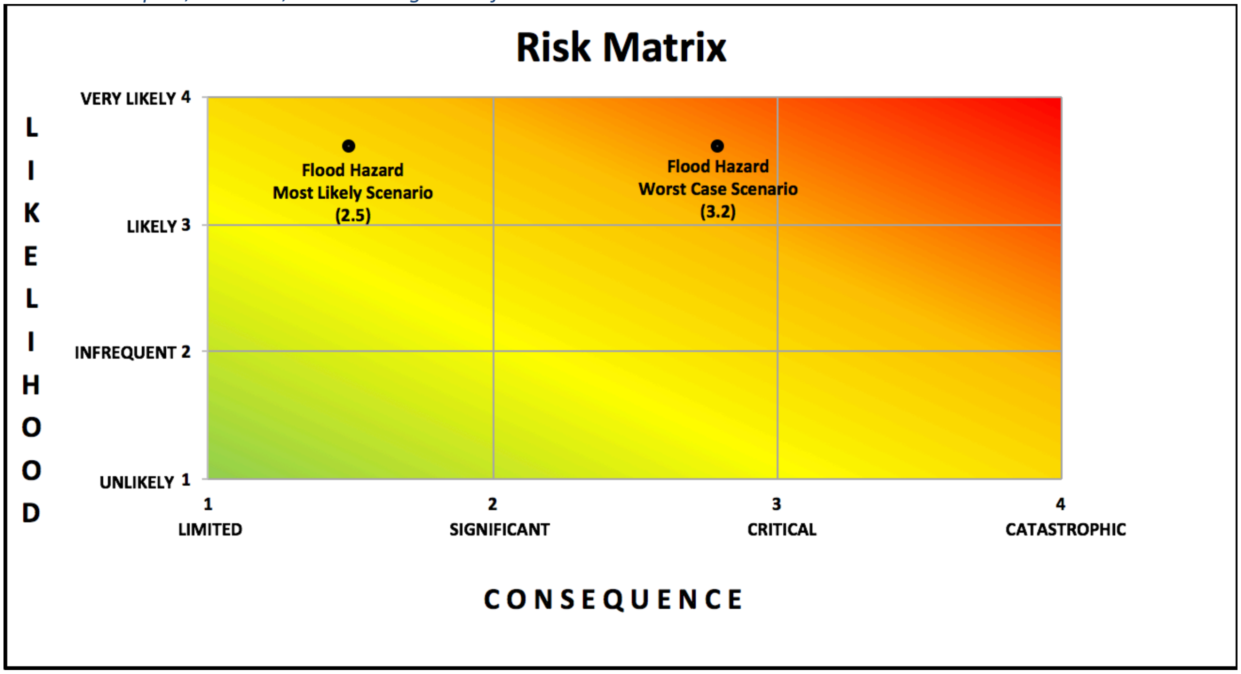
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Flood Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	3.6 Likely-Very Likely		50%
CONSEQUENCE	**Impact**	1.3 Limited-Significant	3 Critical	40%
	Warning Time	4 Short	1 Very Long	5%
	Duration	1 Short	3 Long	5%
TOTAL RISK SCORE		**2.5**	**3.2**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

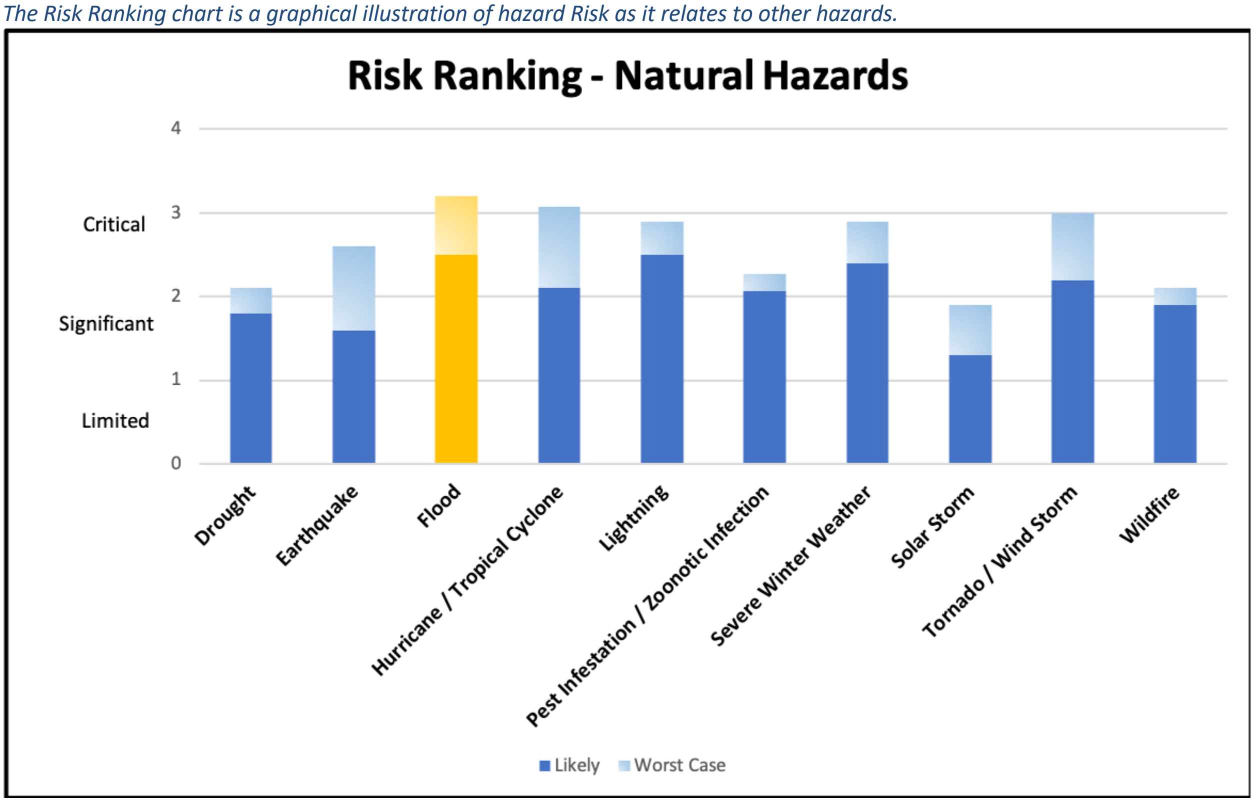
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

FEMA defines flood as "a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties (at least one of which is the policyholder's property) from: overflow of inland or tidal waters, unusual and rapid accumulation, or runoff of surface waters from any source or mudflow."[221] It could also mean the "collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood as defined above."[222]

Flooding typically results from large-scale weather systems that generate prolonged rainfall. Other conditions such as winter snow thaws, over-saturated soil, ice jams that break apart, and urbanization can cause flooding. In Howard County, flooding can follow weather events, including, but not limited to: tropical cyclones (either hurricanes or tropical storms), thunderstorms (convectional and frontal), heavy rain events, winter storms, spring thaws, or a combination of these events.

Flooding is a natural event for rivers and streams. Howard County can be impacted by several different types of flooding:

- Riverine flooding
- Urban flooding

Past flood events in Howard County have shown that many of the streams in the County carry both riverine and flash flood threats.

Riverine flooding occurs when rivers, creeks, streams, reservoirs or channels receive too much water in a short time span, which leads to the excess flow of water over its banks and onto the adjacent floodplain.[223] This type of flooding is often referred to as "overbank" flooding. Riverine flooding generally occurs over a period of days or weeks. One type of riverine flooding is a flash flood. Flash floods involve a rapid rise in water level, high water velocity, and large amounts of debris. These types of floods can cause significant damage, including uprooting of trees, undermining of buildings and bridges, and scouring new channels. The intensity of flash flooding is a function of the amount and duration of rainfall, steepness of the watershed, stream gradients, watershed vegetation, natural and artificial flood storage areas, and configuration of the streambed and floodplain. Dam failure and ice jams can also lead to flash flooding.

[221] FEMA: Flood or Flooding. Retrieved from https://www.fema.gov/flood-or-flooding (last accessed September 26, 2019).

[222] FEMA. Definitions. Retrieved from https://www.fema.gov/national-flood-insurance-program/definitions (last accessed September 26, 2019).

[223] A floodplain is a "land areas adjacent to rivers and streams that are subject to recurring inundation." See *Floodplain Definition and Flood Hazard Assessment*, https://www.oas.org/usde/publications/Unit/oea66e/ch08.htm (last accessed September 26, 2019).

Urban flooding is caused by a combination of excessive rainfall or snow melt events that over-saturate soils and clog drainage areas. The result of urban flooding is ponding or overland flooding. In ponding events, water temporarily accumulates in an area until normal drainage allows it to flow away. Overland floods, which are also known as sheet flooding, occur when intense rainfall simply runs across the ground. In extreme cases, overland floods can rise to depths of more than a foot at relatively high velocities.[224]

[224] For additional information about floods, visit US Department of Commerce, and Noaa. NOAA - National Weather Service. Retrieved from https://water.weather.gov/ahps/ (last accessed September 26, 2019).

Local Context

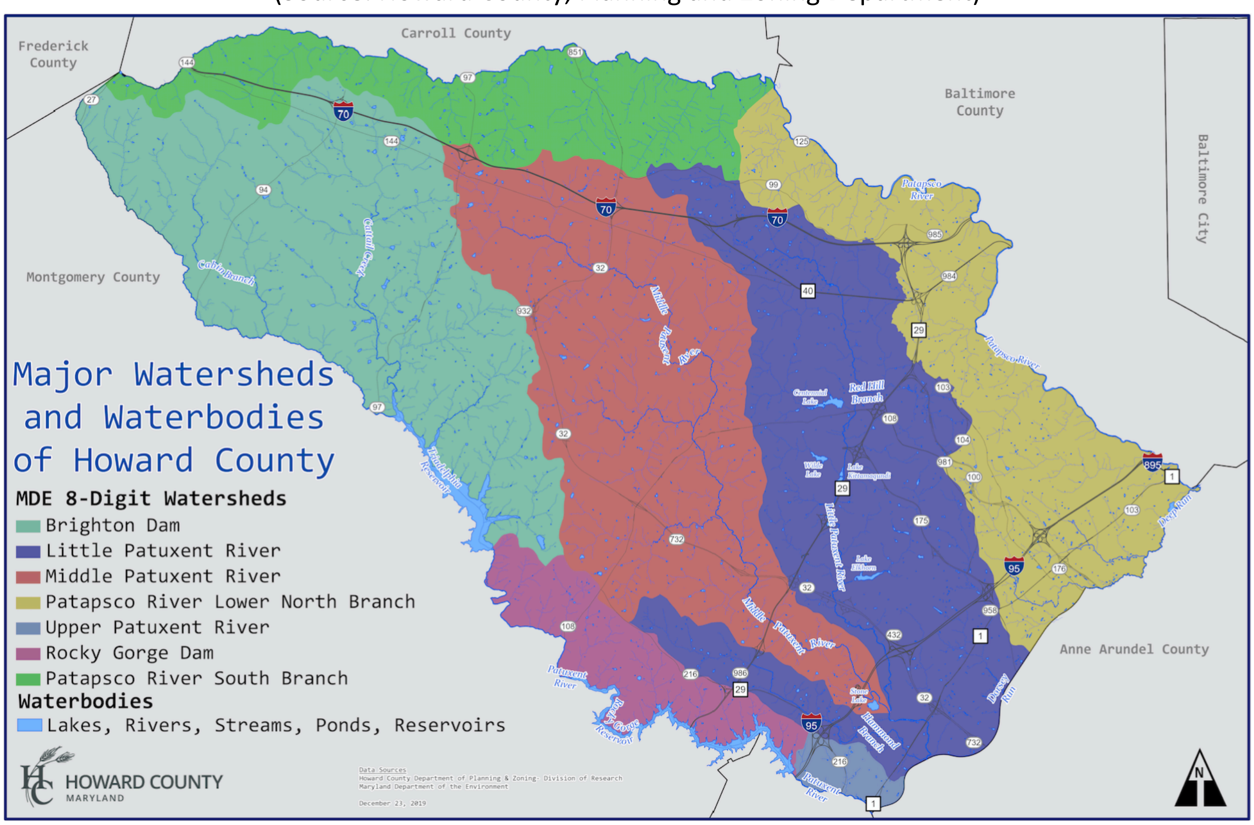
The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Howard County's two major rivers (and their tributaries) are often the origin of riverine flooding in the County. These rivers are the Patuxent, which borders Prince George's and Montgomery Counties to the Southwest, and the Patapsco, which borders Carroll and Baltimore Counties to the North and Northeast. Both rivers are tributaries to the Chesapeake Bay.

In Howard County, the Patuxent River watershed includes the main Patuxent River and two branches, the Middle Patuxent and Little Patuxent. Approximately three-quarters of Howard County's land area lies within the Patuxent watershed. The main Patuxent River branch begins at the most western point of Howard County. This river provides a source of drinking water for the NCR. The river feeds into two reservoirs, the Rocky Gorge and the Triadelphia Reservoir. The Brighton and Howard Duckett Dams preserve these reservoirs. The Middle Patuxent and the Little Patuxent are two of the three major tributaries of the Patuxent River. The Middle Patuxent starts just south of Interstate 70 and runs through the middle of the County. The Little Patuxent runs southeast through Columbia and meets up with the Middle Patuxent in Savage.

Howard County, Major Watersheds

(Source: Howard County, Planning and Zoning Department)



The Patapsco River watershed makes up the remaining quarter of the County's land area. The watershed is located to the extreme north and northwest of the County. The river splits into two branches, which serve as the borders for Carroll, Baltimore, and Howard Counties.

The Patuxent, Middle Patuxent, Little Patuxent, and Patapsco River watersheds can be divided even further to include Cattail Creek, Deep Run, Dorsey Run, and Hammond Branch watersheds. In addition, the County has several other smaller tributaries. These include: Bonnie Branch, Clyde's Branch, Guilford Branch, Plumtree Branch, and the Tiber-Hudson Branch. All of these tributaries are susceptible to riverine flooding.

FEMA prepares and distributes Flood Insurance Rate Maps (FIRMs) to the public, which provide an overview of flood risk and identify County land that is vulnerable to flooding. FIRMs are used to regulate new development and control the substantial improvement or repair of substantially damaged buildings. Flood Insurance Studies (FIS), often developed in conjunction with FIRMs, contain a narrative of the flood history of a community and discuss the engineering methods used to develop the FIRMs. The study also contains flood profiles for studied flooding sources and can be used to determine Base Flood Elevations (BFE) for some areas.[225]

The most recent, Volume 3 Howard County FIS[226][227][228] is dated November 6th, 2013 and compiles previous flood information and data on numerous waterways. A reprinted volume of the FIS is dated June 25th, 2014. The 2018 Updated Flood Mitigation Plan (FMP)[229] for Howard County states that Preliminary Digital Flood Insurance Rate Maps (DFIRMs) were updated. These updates include incorporating the results of any new flood studies into the new DFIRMs and reconciling the new DFIRM data with the flood data in the FMP. These DFIRMs are made in response to the changing conditions affecting the County, including changes in land use, weather events, and improved techniques for assessing floodplains.

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[225] The BFE is defined as the computed elevation to which floodwater is anticipated to rise during the base flood. It serves as the regulatory requirement for the elevation or flood-proofing of structures, which determines the flood insurance premium. See FEMA: Base Flood Elevations, https://www.fema.gov/base-flood-elevation (last accessed October 3, 2019).

[226] Federal Emergency Management Agency. (2013, November 6). FLOOD INSURANCE STUDY, HOWARD COUNTY, MARYLAND AND INCORPORATED AREAS, Volume I. Retrieved from https://www.howardcountymd.gov/LinkClick.aspx?fileticket=fZKU_TK7Z-g=andportalid=0 (last accessed September 26, 2019).

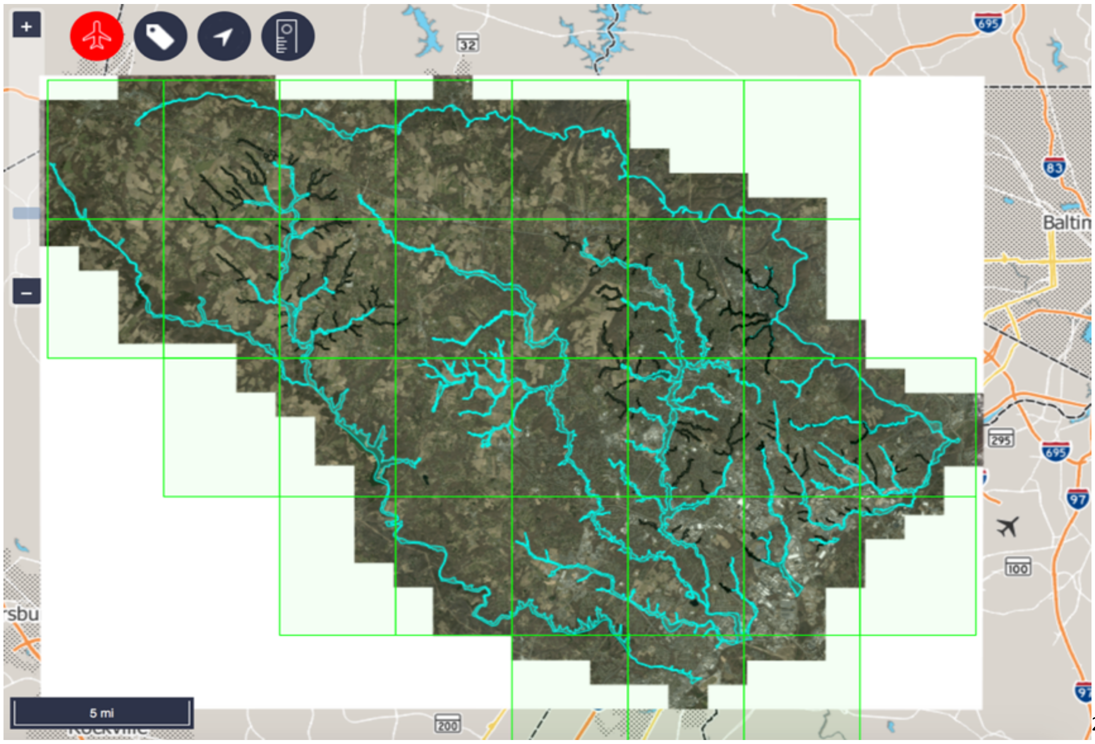
[227] Federal Emergency Management Agency. (2014, June 25). FLOOD INSURANCE STUDY, HOWARD COUNTY, MARYLAND AND INCORPORATED AREAS, Volume II. Retrieved from https://www.howardcountymd.gov/LinkClick.aspx?fileticket=PHrU0eJYTVw%3dandportalid=0 (last accessed September 26, 2019).

[228] Federal Emergency Management Agency. (2013, November 6). FLOOD INSURANCE STUDY, HOWARD COUNTY, MARYLAND AND INCORPORATED AREAS, Volume I. Retrieved from https://www.howardcountymd.gov/LinkClick.aspx?fileticket=eOOzlYgIidY%3dandportalid=0 (last accessed September 26, 2019).

[229] 2018 *Flood Mitigation Plan Update; Howard County, Maryland*, (October 1, 2018), Retrieved from https://www.howardcountymd.gov/LinkClick.aspx?fileticket=4746kpy1PBM=andportalid=0 (last accessed October 3, 2019).

Comparison of Flood Hazard Zones (Effective FIRM vs. DFIRM[230])

(Source: Digital Flood Insurance Rate Map – Howard County)



[231]

As the figure below illustrates, the majority of the flood-prone areas are located in the eastern, and more urbanized, portion of the County. The Howard County FMP states that 5.5% of the County's land area is susceptible to riverine, flash, and urban flooding.[232] According to the National Climate Assessment, "since 1991, the amount of rain falling in very heavy precipitation events has been significantly above average. This increase has been greatest in the Northeast, Midwest, and upper Great Plains – more than 30% above the 1901-1960 average."[233]

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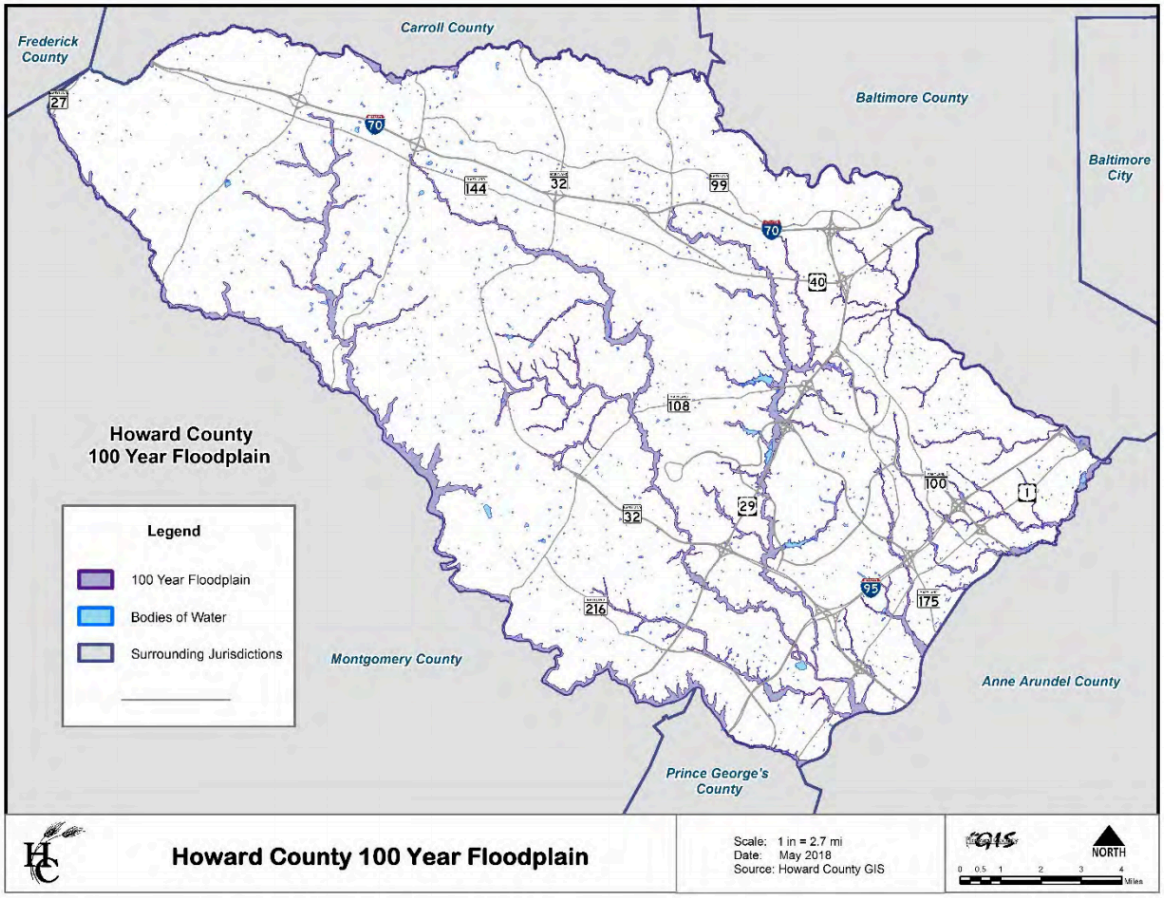
[230] The Howard County DFIRM explains the following flood zones as: "Special Flood Hazard Areas (SFHAs) Subject to Inundation by the 1% Annual Chance Flood. Zone AE (High flood risk) = The flood insurance rate zone that corresponds to the 100-year floodplain that is determined in the Flood Insurance Study by detailed methods. Zone A (High flood risk) = The flood insurance rate zone that corresponds to the 100-year floodplain that is determined in the FIS by approximate methods. Other Flood Areas: Shaded Zone X = The areas of 0.2% annual chance flood (the 500-year floodplain); areas of 1% chance of flood with average depths of less than one foot; or with drainage areas less than one square mile and areas protected by levees from 1% annual chance flood. Ultimate 100-year Floodplain = Areas of future conditions 1% annual chance flood. This is based on County zoning and ultimate development hydrology conditions. 30-acre 100-year Floodplain and 30-acre 500-year Floodplain = The 100-year and 500-year floodplains for drainage areas of 30 acres or greater as defined in Chapter 6 of the Howard County Design Manual, Volume 1. Other Areas: Zone X = Determined to be outside of the 0.2% annual chance (500-year) floodplain. Mandatory flood insurance purchase requirements do not apply here." *Citation*: Floodplain Website Updates - Flood Zones. Retrieved from https://data.howardcountymd.gov/gdfirm/Floodplain Website Updates - flood zones_v3.pdf.

[231] "Approved by FEMA and effective for County development restrictions as of May 6, 2013. Effective for flood insurance requirements as of November 6, 2013." Citation: Digital Flood Insurance Rate Map vs Effective FIRM Panel. Retrieved from https://data.howardcountymd.gov/gdfirm/main_Web.aspx (last accessed September 26, 2019).

[232] 2018 *Flood Mitigation Plan Update; Howard County, Maryland*, (October 1, 2018), Retrieved from https://www.howardcountymd.gov/LinkClick.aspx?fileticket=4746kpy1PBM=andportalid=0 (last accessed October 3, 2019).

[233] National Climate Assessment . Extreme Weather . Retrieved from https://nca2014.globalchange.gov/highlights/report-findings/extreme-weather (last accessed October 3, 2019).

Howard County, 100-year [234]Floodplain
Source: Howard County Department of Technology and Communication Services, GIS Division



[235]

Howard County has particular vulnerabilities to floods. Some of the major cities in the County, such as Ellicott City, Elkridge and Allview are in low-lying areas. The aforementioned dams present another challenge. There are also many low-lying roads and railways in the County.

[234] The 100-year Floodplain does not mean that these events will happen every 100 years, these are estimates based on the probability of the event occurring.
[235] Digital Flood Insurance Rate Map. Retrieved from https://data.howardcountymd.gov/gdfirm/main_Web.aspx (last accessed October 3, 2019).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

The NCDC indicates there have been 56 flooding events in Howard County from 2006 to 2019[236] The NCDC separately categorized flash flooding events. Between 1996 and 2019, the NCDC reports that there were 78 flash flood events.[237]

Notable Incidents in Howard County

Howard County has had numerous flooding incidents, including major events such as Tropical Storm Agnes in 1972, Hurricane Eloise in 1975, Hurricane Floyd in 1999, Tropical Storm Lee in 2011, and most recently, the Ellicott City flash flooding events on July 30th, 2016 and May 27th, 2018. Most incidents are the result of tropical systems, nor'easters, or flash flooding from sudden, short-lived rainstorms. To develop the following flood history narratives, information was pulled from FIS for Howard County and the NCDC database. Detailed descriptions of these events can be found below.

July 24th, 1868 - 18 inches of rain fell on Howard County, causing the Patapsco River to overflow. Witnesses noted that the river rose approximately 30 feet in 30 minutes. The flood resulted in 37 fatalities and caused an estimated $4.7 million[238] in damage.

May 1894 - The Patapsco River flooded, causing extensive property damage. The flood resulted in approximately $175,577[239] in damage.

September 1952 - On Labor Day weekend, Hurricane Able's heavy rains swept through Howard County. A destructive flash flood caused a log jam in the mouth of the Tiber River and resulted in approximately $4.7[240] million worth of damage.

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236 NCDC. Storm Events Database- Flash Floods. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=%28Z%29+FloodandbeginDate_mm=06andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=06andendDate_dd=30andendDate_yyyy=2019andcounty=HOWARD%3A27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24%2CMARYLAND (last accessed October 3, 2019).

237 NCDC. Storm Events Database- Flash Floods. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(C) FlashFloodandbeginDate_mm=06andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=06andendDate_dd=30andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 3, 2019).

238 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $4 million Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

239 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $149,228. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

240 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $4.06 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

August 1st – 4th, 1971 - Heavy rain and flooding caused numerous road closures and damaged several homes. The Patuxent River rose 25 feet in 30 minutes and mud slides damaged roads and bridges. Roads that were flooded and/or damaged included: Owen Brown Road, Morgan Road, Carroll's Mill Road, River Road, Mullinix Mill Road, Howard Chapel Road, Furnace Avenue, Mink Hollow Road, Route 108, Route 32, Centennial Lane, Bethany Lane, and Old Annapolis Road. An estimated $688,763[241] in County property damage was reported.

Tropical Storm Agnes on June 21st – 23rd, 1972 - Another notorious and destructive flooding event in Howard County was caused by Tropical Storm Agnes on June 21st – 23rd, 1972. The Howard County FIS estimates the total property damage from the storm to be as high as $48.4 million.[242] The majority of the damage occurred along the Patapsco River in the Ellicott City and Elkridge areas. The total damage along the Patapsco River was estimated to be approximately $42.3 million.[243] Property damages along the Little Patuxent River totaled about $2.8 million[244] and damages along the Patuxent and Middle Patuxent totaled roughly $602,403.[245] An estimated $1.2 million[246] worth of damages occurred to roads and bridges throughout the County. Meanwhile, the Spatial Hazard Events and Losses Database for the United States (SHEDLUS) database estimates the total property damage from Tropical Storm Agnes to be roughly $13.1 million.[247] This massive flood caused at least three fatalities. The photograph below shows the flooding that occurred along Main Street in downtown Ellicott City.

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241 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $585,400. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

242 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $41.2 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

243 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $36 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

244 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $2.4 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

245 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $512,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

246 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $1.1 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

247 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $11.17 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

Hurricane Agnes, 1972: Flooding along Main Street in Downtown Ellicott City

(Source: The Times Newspaper, 1972)

September 22nd – 26th, 1975 - The remnants of Hurricane Eloise, coupled with snow from a previous storm, resulted in over 12 inches of rain in four days and caused both the Patuxent and Patapsco Rivers to overflow up to 24 feet above normal. Much of Ellicott City and Elkridge were again flooded, as some businesses had just reopened after recovering from the extensive damage caused by Hurricane Agnes. Mud and debris covered the landscape, and homes and businesses were declared unsafe.

June 19th, 1996 - Storms poured 5.5 inches of rain into Howard County and flooded roads, bridges, and properties. Seneca Creek and Bennett Creek overflowed their banks, causing several roads to be temporarily closed. Two fatalities occurred when a couple rafting in the Patapsco River was swept over a dam in the raging current. $97,066[248] in property damage was reported.

September 6th, 1996 - The remnants of Hurricane Fran dropped up to five inches of rain in parts of the County and caused physical damage to the County with 40 mph sustained winds. Minor flooding occurred, 36,300 residents of Howard County lost power, and $40,356[249] of property damage was recorded.

September 9th, 1999 - Thunderstorms moved through the County, producing damaging winds and heavy rainfall across the area. Flooding occurred in Ellicott City, Dorsey, Columbia, and Elkridge. Portions of Route 1 flooded, and cars became trapped by the surrounding water. Water infiltrated homes near Columbia and Dorsey. Precipitation measurements showed 7.39 inches of rain near Columbia and 5.98 inches near Elkridge.

September 16th, 1999 - The remnants of Hurricane Floyd produced high winds and heavy rains that closed 200 roads and streets countywide. Businesses were threatened by the raging waters of the Patapsco River

[248] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $82,500. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[249] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $34,300. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

as its banks overflowed in Ellicott City. Rainfall measurements of two to five inches were reported throughout the day. County officials reported 17 homes were damaged, 350 basements were flooded, two people were rescued, and the Howard Country Fair was shut down for the first time in its 47-year history.

Floods of 2003 - Howard County experienced several floods in 2003. First, on February 22nd, widespread flooding was caused by both melting snow from the snowstorm of February 14th – 18th combined with one and a half to three inches of rain. Several roads closed, including Route 108, Race Road, Furnace Avenue, Triadelphia Mill Road, and Toll House Road and 30 basements flooded. A few months later, from June 7th – 20th, storm systems moved across the region, causing roads and waterways repeatedly to flood for nearly two weeks. River and stream levels remained high throughout this period, fed by up to five inches of rain per day. Several roads were closed multiple times including Furnace Avenue, South Entrance Road, Carris Mill Road, Warfield Road, Route 108, and Lime Kiln Road. On September 23rd, a few days after Hurricane Isabel brought rain to the region, a heavy rainstorm brought two and a half inches of rain in one day and flooded parts of the County. On November 19th, a strong line of thunderstorms brought two to four inches of rainfall, which resulted in the closure of several roads. Finally, on December 11th, a heavy overnight rainfall averaging two to three inches fell on snow-covered grounds, melting the snow. This led to the heightening of rivers and streams as well as the closure of several roads due to rising water.

October 8th, 2005 - Remnants of Tropical Strom Tammy caused prolonged heavy rainfall that measured seven inches in two days. 10 roads in the County flooded, two homes were damaged by the influx of mud, and a water rescue was conducted in Ellicott City.

June 23rd – 26th, 2006 - A storm system moving from the south caused torrential rain that continued for four days. The ground was saturated and low-lying areas flooded as the area accumulated more than 10 inches of rain. A two to three foot storm surge, coupled with flood water, washed away part of the Vollmerhausen Road bridge and forced the closing of minor roads. Main Street in Ellicott City flooded, causing a broken sewer line.

July 23rd, 2008 - A slow-moving cold front produced a wave of heavy showers in the afternoon and evening. Flash flooding occurred, closing several roads including I-95, the nation's main thoroughfare on the East Coast, near Elkridge.

July 30th, 2016 - A significant flooding event occurred on July 30th, 2016, when a strong storm dropped six inches of rain over Ellicott City over a span of two hours.[250] Massive flooding caused extensive damage to businesses and homes on Main Street in Old Town, Ellicott City. The storm took two lives and caused at

[250] The Baltimore Sun, *2 Dead, Emergency Declared After Historic Ellicott City Ragaed By Flash Flood,* http://www.baltimoresun.com/news/maryland/howard/ellicott-city/bs-md-ellicott-city-flood-20160731-story.html (last accessed October 6, 2016)

least $23.9 million[251] in estimated damages. The storm caused extensive damage to 90 businesses and 107 homes. The images below are from the July 2016 flooding.

May 27th, 2018: - There were a series of heavy thunderstorms causing excessive rainfall in short period of time. This event happened just 22 months after the 2016 flood in Ellicott City and Catonsville. According to the NOAA, "The heavy rainfall, between six to 12 inches in the heaviest band, caused catastrophic damage, especially in Historic Ellicott City." There was flood damage to buildings, infrastructure, and vehicles. Roads washed out, land eroded and there were localized landslides. Emergency swift-water

[251] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2016 was $22.4 million. Citation: US Inflation Staff, C. (2019, September 12). US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

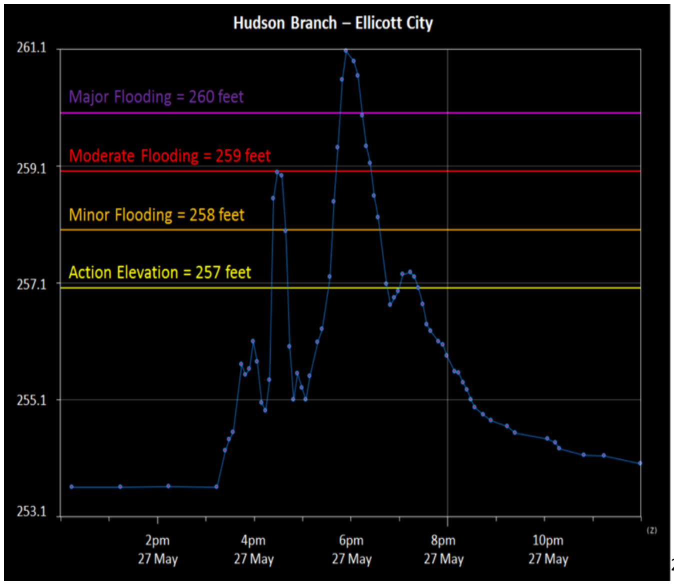
rescue operations were performed.[252] There was one fatality during the flood. According to the NOAA, this "person died while trying to help a woman who was seeking assistance after the first flood wave."253 The graphs below depict the rainfall totals through the evening and associated water levels.

Ellicott City, MD – May 27, 2018

Duration	Max Rainfall in Duration	Time of Occurrence
1 minute	0.16"	4:15pm-4:16pm
5 minutes	0.56"	4:15pm-4:20pm
10 minutes	0.96"	4:11pm-4:21pm
15 minutes	1.44"	4:06pm-4:21pm
30 minutes	1.84" 1.84"	3:53pm-4:22pm 5:20pm-5:50pm
60 minutes	2.68" 2.84"	3:20pm-4:20pm 5:00pm-6:00pm
2 hours	5.00"	3:53pm-5:53pm
3 hours	6.56"	3:15pm-6:15pm

Information obtained from the Ellicott City (ELYM2) rain gauge. Data is preliminary and subject to correction. This gauge reports in 0.04" increments. 254

[252] MEMA. (2018, July 23). STATE OF MARYLAND MAY 2018 SEVERE WEATHER AND FLOODING AFTER-ACTION REPORT (AAR). Retrieved from https://mema.maryland.gov/Documents/May-2018-Severe-Weather-and-Flooding-AAR-FINAL.pdf (last accessed October 4, 2019).
[253] US Department of Commerce, and Noaa. (2018, July 2). May 27th, 2018 Flooding - Ellicott City and Catonsville, MD. Retrieved from https://www.weather.gov/lwx/EllicottCityFlood2018 (last accessed September 27, 2019).
[254] US Department of Commerce, and Noaa. (2018, July 2). May 27th, 2018 Flooding - Ellicott City and Catonsville, MD. Retrieved from https://www.weather.gov/lwx/EllicottCityFlood2018 (last accessed September 27, 2019).



[255]

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Flood in Howard County	
Historical Average (time period)	56 flood events between (2006-2019) and 78 flash flood events between (1996-2019)
Historical Annual Probability	30%+ chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	11-30% + chance of annual occurrence
Future Likelihood Score[73]	3.6 (Likely- Very Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

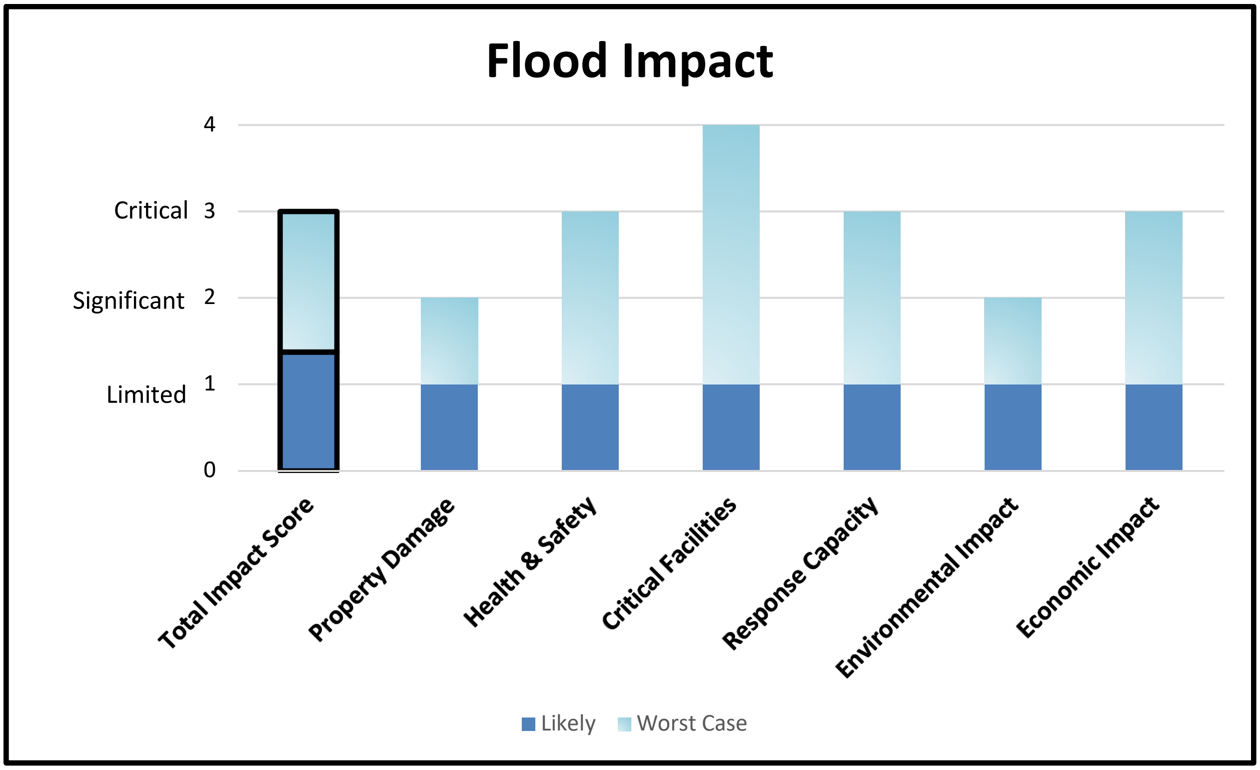
Considerations: The future annual probability of a Flood is 11-30% + chance of annual occurrence, or, one event every 3-9 years. There is an increased risk of flood events going forward based on the National Climate Assessment, which projects increased frequency of severe storms and rain. An expected increase in rainfall levels and extreme storms may result in a slight increase in the likelihood of flooding.[256] Aging dam infrastructure may also contribute to a slight increase in the likelihood of flooding in the future.[257] Other considerations include existing buildings in the floodplain.

[255] US Department of Commerce, and Noaa. (2018, July 2). May 27th, 2018 Flooding - Ellicott City and Catonsville, MD. Retrieved from https://www.weather.gov/lwx/EllicottCityFlood2018 (last accessed September 27, 2019).
[256] National Climate Assessment . Extreme Weather . Retrieved from https://nca2014.globalchange.gov/highlights/report-findings/extreme-weather (last accessed October 3, 2019).
[257] *Manmade Hazard Identification and Risk Assessment Workshop (unpublished)*, Howard County OEM (2014).

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Flood Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* One hour.	*Very Long.* Several days.
DURATION	*Short.* Two hours.	*Long.* 48 hours.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario

Flood Consequence Analysis **Likely**		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ Limited critical and non-critical infrastructure damage. ▪ Debris on the roadway is expected. ▪ Limited washouts at road edges and around some culverts are expected to be damaged.
HEALTH AND SAFETY	*Limited*	▪ Zero deaths are expected. Vehicle in water and attempting to escape, walking near water, or electrocution are the most common causes of death. ▪ Two injuries are expected. Vehicle collisions and stranded drivers trying to escape are the most common causes of injuries.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – shutdown unlikely. ▪ *Information/Communications* – Outage unlikely. ▪ *Transportation* –Minor flooding on roadways, blocking traffic and causing the need for rescue of a few individuals who became stranded while trying to cross through the flood waters. Several flooded roadways, fast moving water, impact traffic, and law enforcement and public works required to block roads and recover.
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. ▪ *Fire and Rescue* – Local resources adequate. Limited impact to response capability. Additional personnel will be necessary to assist with stranded motorists. ▪ *Health* – Local resources adequate. HD has COOP plans in place to ensure essential functions continue either on site (if possible) or at an alternate location. ▪ *Public Works* – Local resources adequate. Minimal Impact on response capability and continuity of operations.
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal Impact with a possible short-term spike in water pollution. ▪ Mudslides or fallen trees can cause serious erosion or sediment pollution to the local water resource.
ECONOMIC IMPACT	*Limited*	▪ Millions of loss in dollar value in low lying areas. ▪ Structural and business loss and disruption of transportation network in economic consequences.
TOTAL IMPACT[258]	***Limited-Significant***	▪ **Total Impact Score: 1.375 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[258] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

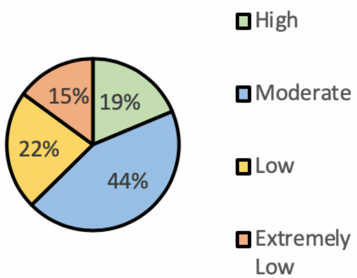
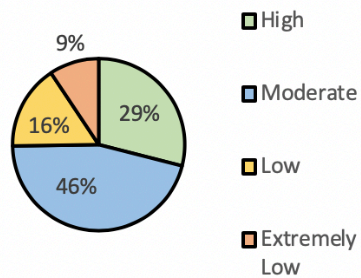
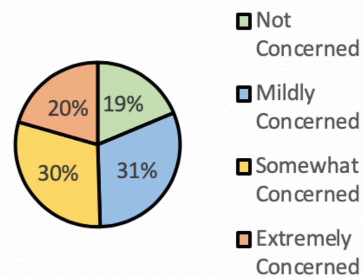
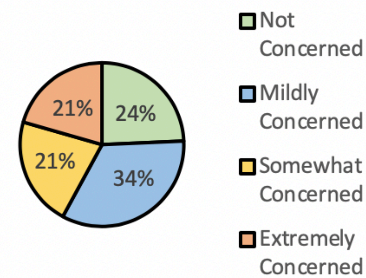
The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

Flood Consequence Analysis Worst-Case				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Significant*	▪ Critical and non-critical infrastructure will be damaged. ▪ Earthen dams being in danger. ▪ Ellicott City, Elkridge, and other low-lying areas to be affected and downed trees and wires expected. ▪ Major structural damage due to flowing water. ▪ Downed trees, downed power lines, washed out roadways, and pipe/ culvert failures are expected.		
HEALTH AND SAFETY	*Critical*	▪ Zero to ten deaths are expected. Vehicle in water and attempting to escape, walking near water, electrocution, or drown in home are the most common causes of death. ▪ 20-30 injuries are expected. Vehicle in water and attempting to escape, walking near water, electrocution, roof collapse, lightning, or hydroplane are the most common causes of injuries.		
CRITICAL FACILITIES	*Catastrophic*	▪ *Utilities* – Some utilities could be shut down for one week- one month. ▪ *Transportation* – Bridges, railways, and roads will be shut down or out of service. ▪ *Information/Communications* – Phone and electrical/power facilities will be out of service.		
RESPONSE CAPACITY	*Critical*	▪ *Police* – Local resources adequate. No impact on response capability and continuity of operations. ▪ *Health* – Moderate need for state or federal assistance. HD has COOP plans in place to ensure essential functions continue either on site (if possible) or at an alternate location. ▪ *Fire and Rescue* – Local resources adequate. Limited impact to response capability. Additional personnel will be required to assist with the call volume. ▪ *Public Works* – Moderate need for state or federal assistance. Significant impact as crews work multiple consecutive days in response.		
ENVIRONMENTAL IMPACT	*Significant*	▪ Minimal impact on air quality. ▪ Impacts to land resources will be limited to areas that are affected by flooding. ▪ Most significant impact is to water resources due to increased water pollution due to the flooding. ▪ Materials in the floodwaters can cause erosion, clogging water channels, or destroying animal habitats along the water's edge.		
ECONOMIC IMPACT	*Critical*	▪ Hundreds of millions and up of loss in dollar value. ▪ Business closures, costly clean-up, loss of employment, and transportation infrastructure disruption in economic consequences. ▪ Critical economic impact.		
TOTAL IMPACT[259]	***Critical***	▪ **Total Impact Score: 3 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

[259] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Flood Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
 *Average: 2.66* *Low - Moderate*	 *Average: 2.94* *Low - Moderate*	 *Average: 2.52* *Mildly Concerned - Somewhat Concerned*	 *Average: 2.38* *Mildly Concerned - Somewhat Concerned*

Hurricane/Tropical Cyclone

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

Hurricanes, tropical storms, and typhoons are collectively known as tropical cyclones. NOAA defines a tropical cyclone as a "warm-core non-frontal synoptic-scale cyclone, originating over tropical or subtropical waters, with organized deep convection and a closed surface wind circulation about a well-defined center. Once formed, a tropical cyclone is maintained by the extraction of heat energy from the ocean at high temperature and heat export at the low temperatures of the upper troposphere."[260]

Risk Profile

The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

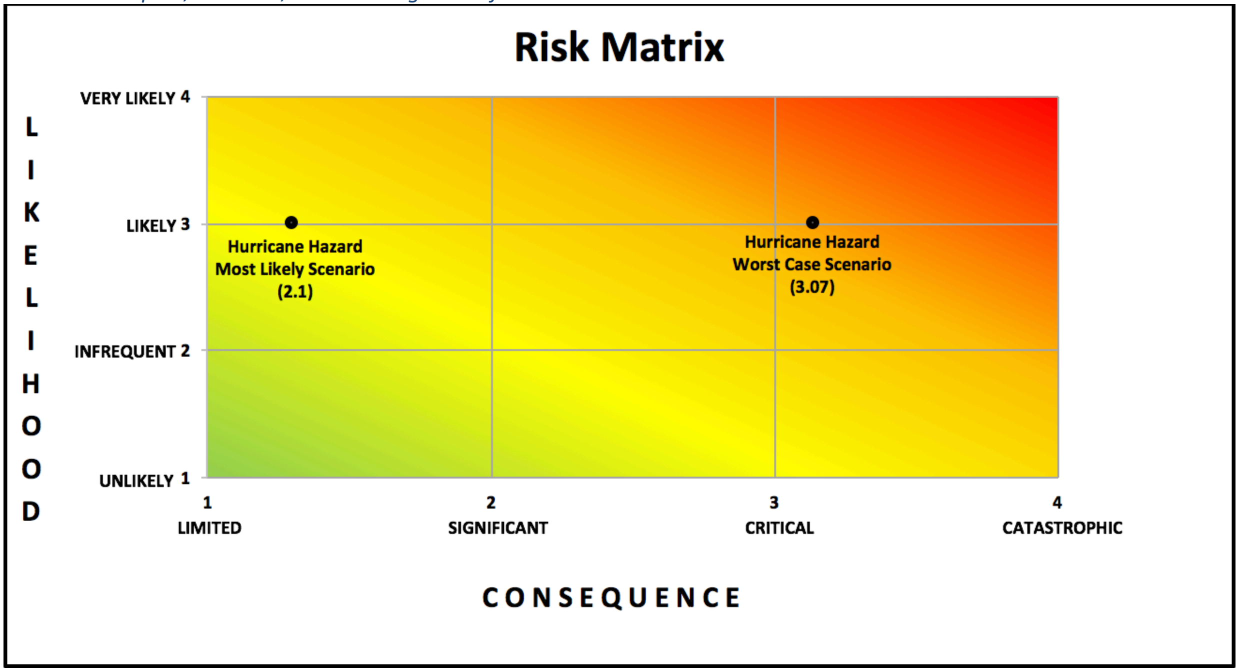
Hurricane/Tropical Cyclone Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	3 Likely		50%
CONSEQUENCE	**Impact**	1.3 Limited-Significant	3.3 Critical-Catastrophic	40%
	Warning Time	1 Very Long	1 Very Long	5%
	Duration	2 Moderate	4 Very Long	5%
TOTAL RISK SCORE		**2.1**	**3.07**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

[260] *Glossary of National Hurricane Center Terms*, http://www.nhc.noaa.gov/aboutgloss.shtml#TROPCYC (last accessed September 26, 2019).

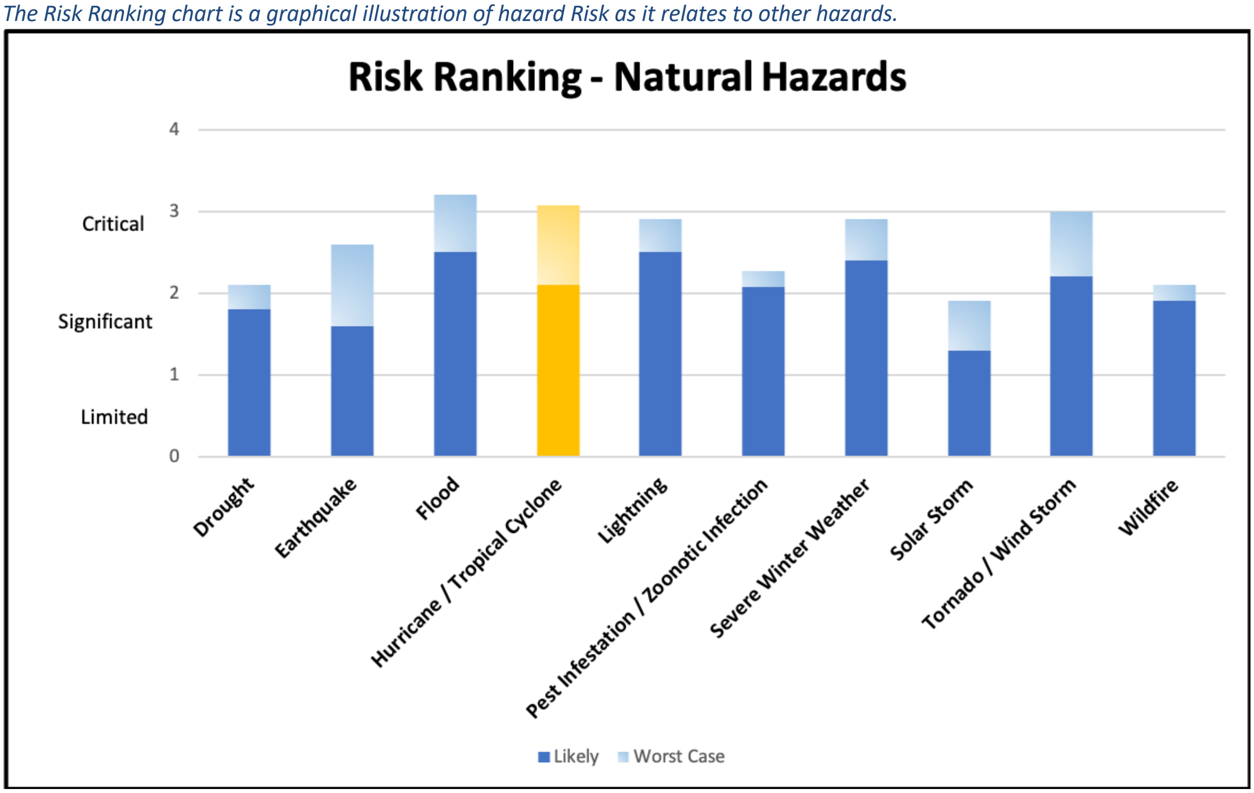
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Tropical cyclones are among the most financially devastating naturally occurring hazards in the United States. Hurricanes, the strongest type of the tropical cyclones in the United States, generate hazards that can cause extensive damage such as high winds, heavy rainfall, tornadoes, and storm surge. While there is potential for hurricane force winds to occur in Howard County, its inland location removes it from the Atlantic coastline and places it north of the warm Carolina waters. Instead, its location makes the County more vulnerable to tropical storms and tropical depressions.

As a tropical cyclone strengthens, it can be become a tropical depression with wind speeds up to 38 mph. As a storm intensifies, it becomes a tropical storm when maximum sustained wind speeds range from 39 to 73 mph. A storm of that magnitude is given a “name” once it reaches tropical storm intensity. Further development can produce a hurricane, which can be described as a well-defined low-pressure system with circulation around the “eye” or center of the storm.[261]

The table below provides a concise explanation of each tropical cyclone category.[262]

Tropical Cyclone - Wind Speeds Categories
(Source: NOAA)

Category	Wind Speed	Definition
Tropical Depression	< 38 mph	An organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds of 38 mph or less.
Tropical Storm	39 -73 mph	An organized system of strong thunderstorms with a defined surface circulation and a wind speed range from 39 to 73 mph.
Hurricane	74+ mph	An intense tropical low-pressure system of strong thunderstorms with a well-defined surface circulation and a sustained wind speed of 74 mph or more. The term hurricane is used for Northern Hemisphere tropical cyclones east of the International Dateline to the Greenwich Meridian.

The table below provides a concise explanation of each Hurricane category.

[261] See generally *NOAA FAQ*, https://www.aoml.noaa.gov/hrd/tcfaq/A11.html (last accessed September 2019).
[262] For additional information about hurricanes and tropical storms, see *NOAA’s National Hurricane Center*, http://www.nhc.noaa.gov/ (last accessed September 26, 2019).

Staffir-Simpson Hurricane Wind Scale[263]
(Source: NHC and NOAA)

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph 64-82 kt 119-153 km/h	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph 83-95 kt 154-177 km/h	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks
3 (Major)	111-129 mph 96-112 kt 178-208 km/h	Devastating damage will occur: Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (Major)	130-156 mph 113-136 kt 209-251 km/h	Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (Major)	157 mph or higher 137 kt or higher 252 km/h or higher	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Tropical cyclone risk in the United States extends along the entire East Coast (from Florida to Maine), the Gulf Coast, and Hawaii. Based on historical storm tracks, it shows that the southern Atlantic Coast and the Gulf Coast are at the greatest risk. As one moves further inland and/or north along the Atlantic Coast where colder ocean waters persist, the threat of powerful hurricanes diminishes. However, the threat of

263 "The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous, however, and require preventative measures. In the western North Pacific, the term "super typhoon" is used for tropical cyclones with sustained winds exceeding 150 mph." Citation: NATIONAL HURRICANE CENTER and CENTRAL PACIFIC HURRICANE CENTER. Saffir-Simpson Hurricane Wind Scale. Retrieved from https://www.nhc.noaa.gov/aboutsshws.php.

tropical storms and remnants of hurricanes is still prevalent. The greatest threat for the occurrence of a tropical cyclone in Howard County is during the Atlantic Basin Hurricane season, which runs from June 1st to November 30th each year. The hurricane/tropical storm hazard affects the entire County.

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

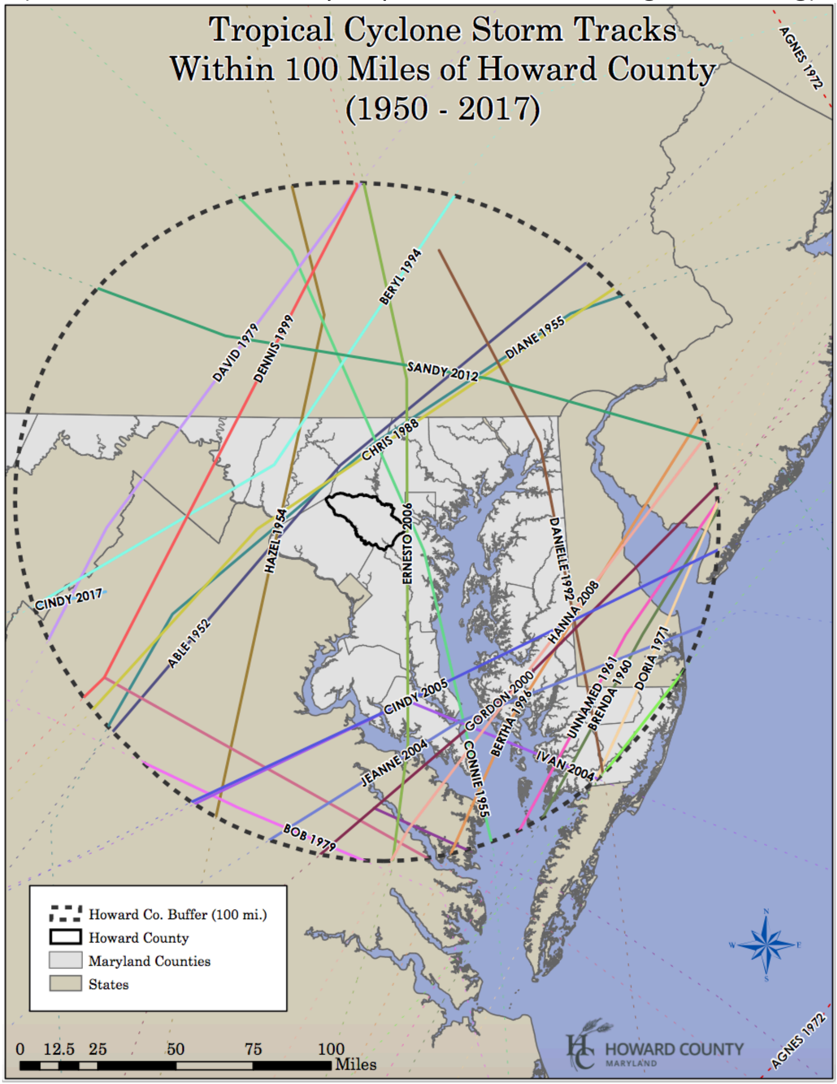
According to the NCDC database, there has not been a Hurricane in Howard County, Maryland since 1950 (categorized by passage of the eye directly over the County). Despite the eyes of storms not directly passing over Howard County, the County has felt the effects of nearby hurricanes. The database does list two tropical storm events that have impacted Howard County from 1950 to 2019.[264] Other storms were downgraded to either tropical storms or tropical depressions by the time they reached the Mid-Atlantic region, which is typical for this region. Although not all of these storms brought significant damage, most brought heavy rain and increased high winds across Howard County. The map below depicts all storm tracks to occur within 100 miles of Howard County from 1950-2017.[265]

[264] NCDC. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(Z)+Hurricane+(Typhoon)andbeginDate_mm=06andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=06andendDate_dd=30andendDate_yyyy=2019andcounty=ALLandhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 4, 2019).

[265] The map shown provides the most up to date data collected from Subject Matter Experts during the 2019 HIRA update.

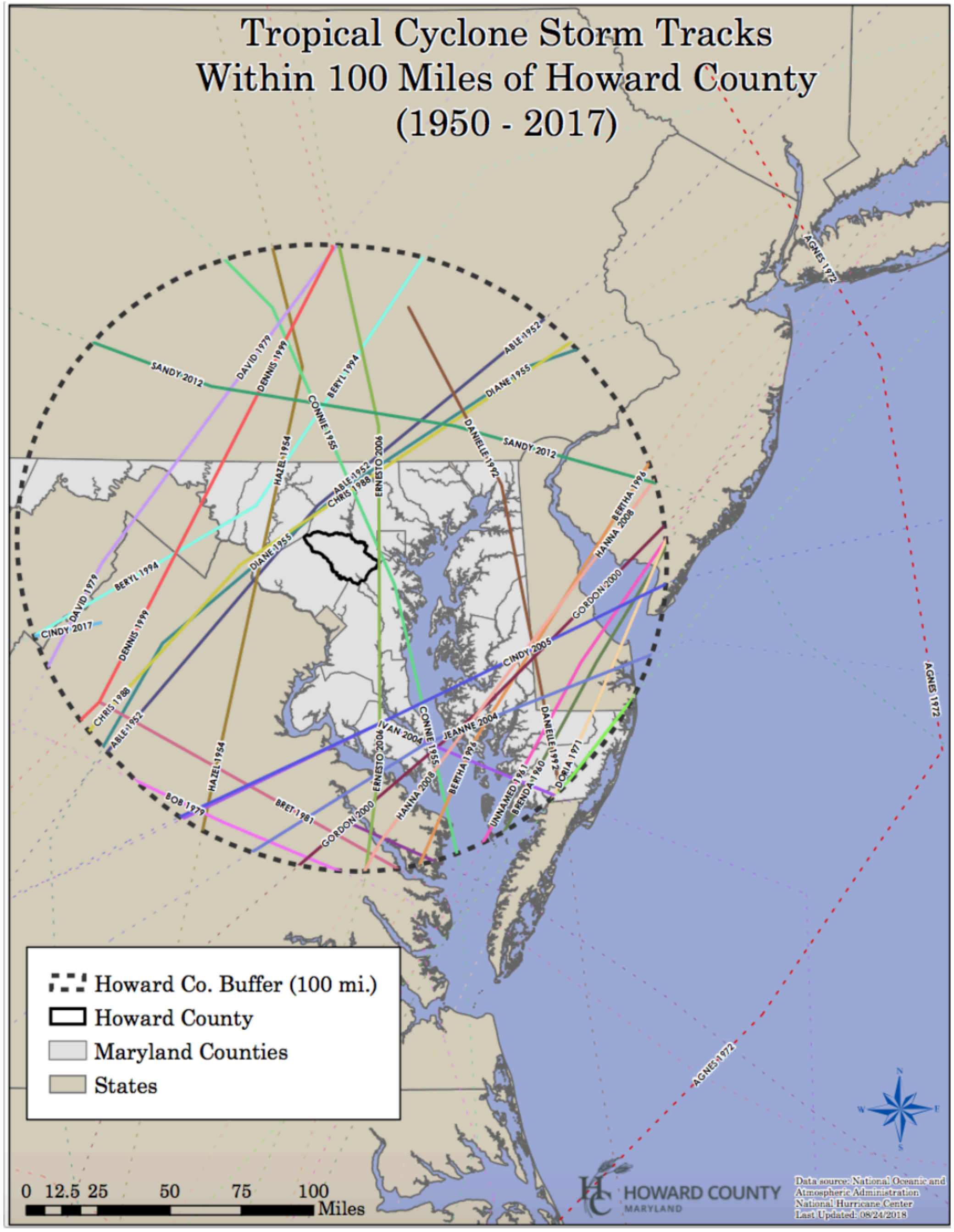
Howard County: Storm Tracks, 1950 –2017

(Source: Howard County Department of Planning and Zoning)



Howard County: Storm Tracks, 1950 –2017

(Source: Howard County Department of Planning and Zoning- Expanded version to include Agnes)[266]



266 Agnes had devastated the region. The storm tracked off-shore, making visibility on a map difficult. The additional map was provided by Subject Matter Experts to show the storm's path and to highlight that despite its location, it still had a significant impact on the region.

Notable Incidents in Howard County

Below is a list of notable tropical cyclonic events since 1950 that have significantly impacted Howard County.

September 1st, 1952 – Tropical Storm Able

On the night of August 30th, 1952, Hurricane Able made landfall over Beaufort, South Carolina. As the storm moved northward across South Carolina, North Carolina, and Virginia, Able was downgraded to a tropical storm. On September 1st, the center of Tropical Storm Able had moved over the western portion of Howard County. Able brought winds of 35 to 40 mph and gusts up to 50 mph. The peak wind gust at the Washington National Airport was 60 mph. The rain associated with the storm caused isolated flooding, while the wind brought down trees and branches and caused power outages to the region.[267]

October 15th, 1954 – Hurricane Hazel

Hurricane Hazel made landfall 250 miles south of Wilmington, North Carolina as a Category 3 storm. Hazel maintained its hurricane force winds as it rapidly progressed up north. From Southern Virginia to Central Pennsylvania, Hazel produced Category 1 hurricane force winds. The eye of the storm passed to the west of Washington, D.C. and then near Hagerstown, Maryland. There were reports of peak gusts in an excess of 100 mph in Howard County.

August 15th, 1955 – Tropical Storm Connie

On August 12th, Connie made landfall over the Outer Banks of North Carolina as a Category 1 Hurricane. Hurricane Connie then moved northward across North Carolina. By the time Connie reached Maryland's Eastern Shore on August 13th, it had weakened to a tropical storm. Tropical Storm Connie then moved northwest across the Chesapeake and towards north of Baltimore City, bringing with it 50 mph winds and a substantial amount of rain. Howard County's proximity to Baltimore City indicates that the region experienced a substantial amount of rainfall.

August 18th, 1955 – Tropical Storm Diane

Only five days after Connie made landfall, on August 17th, Category 1 Hurricane Diane made landfall near Wilmington, North Carolina. Hurricane Diane was quickly downgraded to a tropical storm as it moved inland. The tropical storm then moved northwest across North Carolina and Virginia before shifting to the northeast over North-Central Virginia. On August 18th, the center of Tropical Storm Diane tracked through the eastern portion of Frederick County, Maryland, producing winds between 50-60 mph. As a result of its proximity, Tropical Storm Diane brought a significant amount of rain and flooding to Howard County.

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[267] *Monthly Weather Review,* August 1952. Available at http://docs.lib.noaa.gov/rescue/mwr/080/mwr-080-08-0138.pdf (last accessed September 26, 2019).

June 21st, 1972 – Tropical Storm Agnes

The Howard County FIS estimates the total property damage from Tropical Storm Agnes to be as high as $48.4 million.[268] The majority of the damage occurred along the Patapsco River in Ellicott City and Elkridge areas. The total damage along the Patapsco River was estimated to be approximately $42.3 million.[269] Property damages along the Little Patuxent River totaled about $2.8 million[270] and damages along the Patuxent and Middle Patuxent totaled roughly $602,403[271] An estimated $1.2 million[272] worth of damages occurred to roads and bridges throughout the County. Meanwhile, the SHEDLUS database estimates the total property damage from Tropical Storm Agnes to be roughly $13.1 million.[273]

September 22ed, 1975 – Hurricane Eloise

The remnants of Hurricane Eloise, coupled with snow from a previous storm, resulted in over 12 inches of rain in four days and caused both the Patuxent and Patapsco Rivers to overflow up to 24 feet above normal. Much of Ellicott City and Elkridge were again flooded, as some businesses had just reopened after recovering from the extensive damage caused by Tropical Storm Agnes. Mud and debris covered the landscape, and homes and businesses were declared unsafe.

September 7th, 1999 – Tropical Storm Dennis

The remnants of Hurricane Dennis tracked across Western Maryland on September 7th. The hurricane brought heavy rains and flooding throughout the County. Strong winds also caused power outages throughout the region.

September 16th, 1999 – Hurricane Floyd

The remnants of Hurricane Floyd produced high winds and heavy rains which closed 200 roads and streets countywide. Businesses were threatened by the raging waters of the Patapsco River as its banks overflowed in Ellicott City. Rainfall measurements of two to five inches were reported throughout the day. County officials reported 17 homes damaged, 350 basements flooded, two people rescued, and the Howard Country Fair was shut down for the first time in its 47-year history.

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268 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $41.2 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

269 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $36 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

270 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $2.4 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

271 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $512,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

272 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $1.1 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

273 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $11.17 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

September 19th, 2003 – Hurricane Isabel

Hurricane Isabel made landfall on September 18th as a Category 2 hurricane. As the storm moved across Southern Virginia, it weakened to tropical storm status. The rain associated with Hurricane Isabel caused isolated flooding, while strong wind brought down power lines and left more than 65,000 homes without power. At one point, 80-90 roads were deemed impassable due to fallen trees.[274]

September 3rd, 2006 – Tropical Storm Ernesto

Tropical Storm Ernesto made landfall on September 1st in North Carolina. The storm maintained its strength as it tracked northward from North Carolina to Virginia, and then into Southern Maryland. Ernesto's center passed just east of Howard County, bringing upwards of five inches of rain and wind guests over 50 mph. Ernesto's winds caused over 44,000 residents in the region to lose power.[275]

September 6th, 2008 – Hurricane Hanna: Hurricane Hanna made landfall in Myrtle Beach, South Carolina. The hurricane became an extratropical cyclone as it moved up the Eastern Seaboard towards Canada.[276] There were 537 deaths reported, mostly as a result of flooding in Haiti, and seven deaths were reported on the east coast of the United States.[277] Additionally, the storm became a tropical depression when "the track of the cyclone stayed east of the Baltimore-Washington metropolitan area. Maximum sustained winds generally averaged between 20-35 mph through the afternoon of the 6th."[278]

August 30th, 2011 – Tropical Storm Irene

In late August and early September 2011, Howard County was affected by a downgraded Hurricane Irene, which became a tropical storm by the time it reached Central Maryland. Hurricane Irene originally made landfall on August 27th, 2011 as a Category 1 hurricane near Cape Lookout, North Carolina, with maximum sustained winds of 85 mph. The storm followed the Atlantic coastline as a Category 1 hurricane, which then made a second landfall near Little Egg Inlet, New Jersey the following morning. In Howard County, tens of thousands were left without power. Specifically, on August 27th, 2011, Howard County experienced 30,000 outages as Hurricane Irene advanced[279]. Initial estimates indicated damage of about $2.1 million[280] in Howard County, where the storm severely damaged two homes and caused significant damage to four

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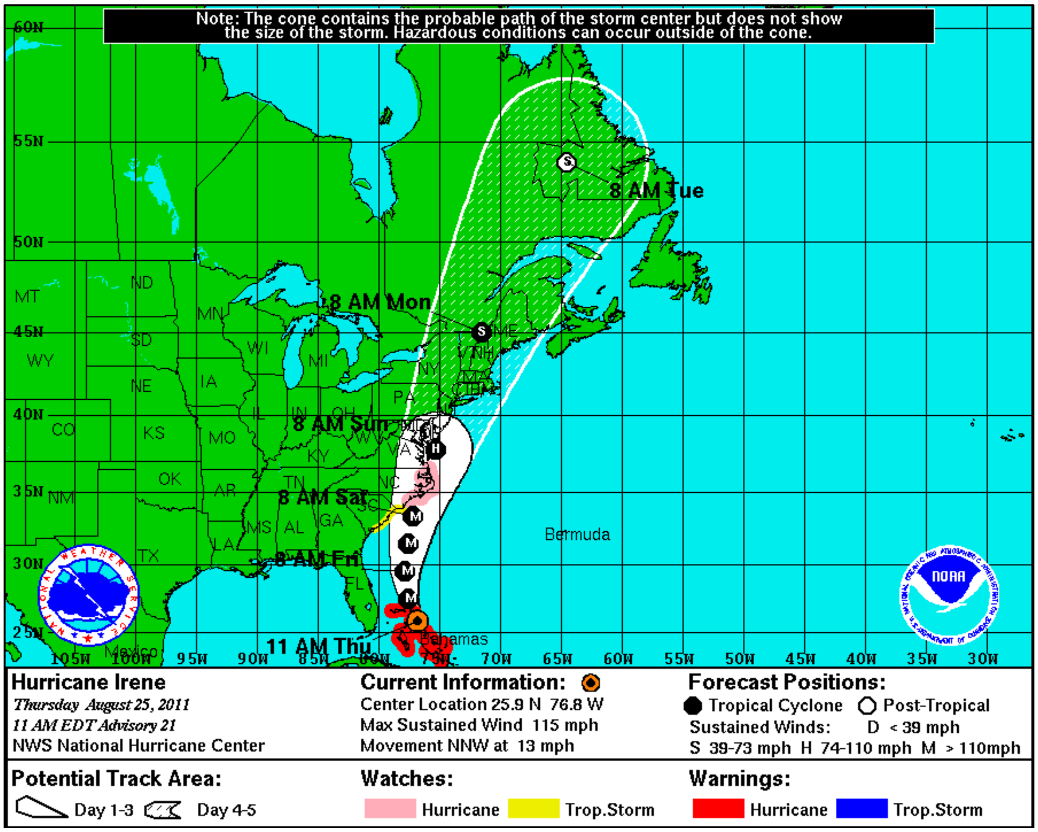
[274] *NOAA National Hurricane Center's Tropical Cyclone Report; Hurricane Isabel*. Available at https://www.nhc.noaa.gov/data/tcr/AL132003_Isabel.pdf (last accessed September 26, 2019).
[275] Desmon, Stephanie and Gadi Dechte, *Ernesto's Wind Gusts Punched Away at Maryland*, Baltimore Sun, September 3, 2006, available at http://articles.baltimoresun.com/2006-09-03/news/0609030063_1_arundel-county-rain-anne-arundel (last accessed October 4, 2019).
[276] US Department of Commerce, and Noaa. (2016, January 14). Hurricane Hanna - September 6, 2008. Retrieved from https://www.weather.gov/mhx/Sep062008EventReview (last accessed October 8, 2019).
[277] US Department of Commerce, and Noaa. (2016, January 14). Hurricane Hanna - September 6, 2008. Retrieved from https://www.weather.gov/mhx/Sep062008EventReview (last accessed October 8, 2019).
[278] US Department of Commerce, & Noaa. (2018, December 12). Hurricane History. Retrieved from https://www.weather.gov/lwx/hurricane_history.
[279] Brian M. Rosenthal, C. K. (2011, August 27). More than 1 million without power, phone service as Hurricane Irene advances. Retrieved from https://www.washingtonpost.com/blogs/post_now/post/thousands-without-power-as-hurricane-irene-advances/2011/08/27/gIQAI2X1iJ_blog.html.
[280] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2011 was $1.9 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

others in the Ellicott City area. The highest rainfall totals in Howard County were around four to five inches along the eastern part of the County. The path of the storm is shown in the figure below.

Hurricane Irene Actual and Projected Storm Path as of 11 a.m. August 25th, 2011[281]

(Source: NOAA)



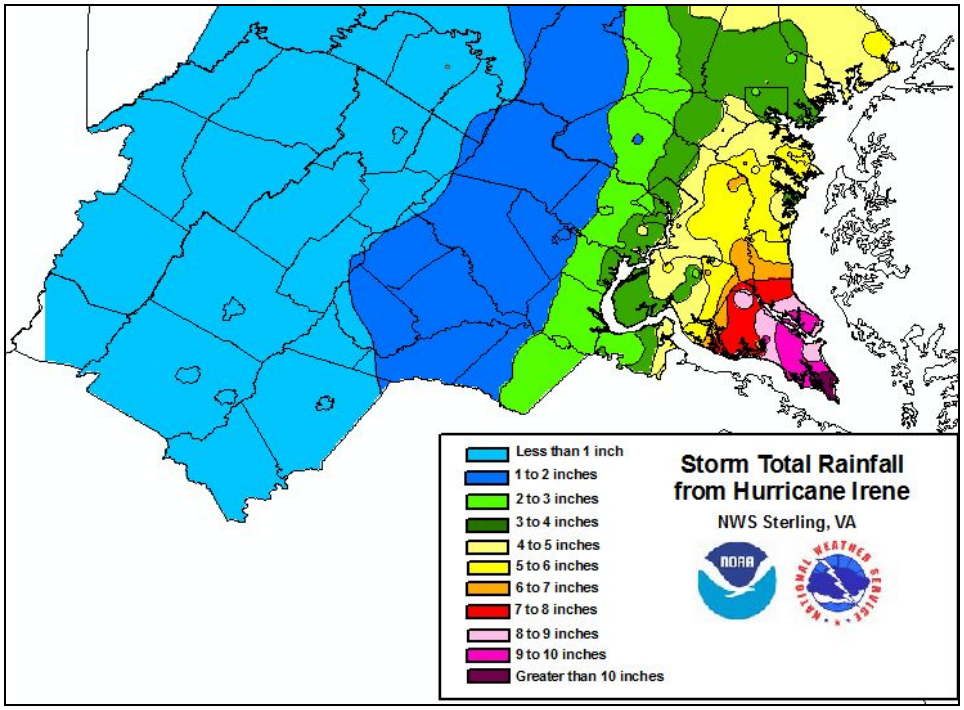
In Maryland, Hurricane Irene caused tropical storm force winds and torrential rains. More than 700,000 people were left without power across the State. Total damage in Maryland was estimated at approximately $18.2 million[282], with the most severe damages occurring in the Eastern and Southern portions of the State. A Presidential Disaster Declaration (FEMA-DR-4034) was declared for 13 of the 24 counties in Southern and Eastern Maryland as a result of this storm.

The first two figures below depict the total rainfall and wind speeds for Hurricane Irene. The rainfall figure shows rainfall totals in Howard County were around two inches in the western part of the County, with the rainfall total increasing to the east. The highest rainfall totals in Howard County were between four to five inches along the eastern part of the County.

[281] Additional information, including but not limited to, maps and graphs, were provided for Hurricanes / Tropical Storms that caused a significant impact to the region.

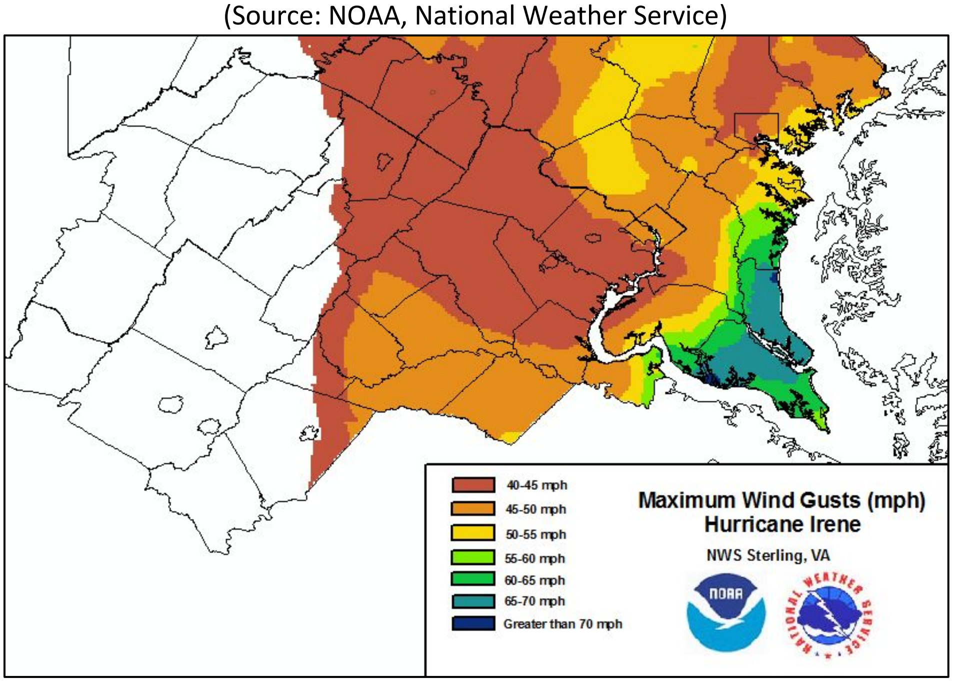
[282] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2011 was $16 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

Hurricane Irene: Rainfall Totals for Maryland
(Source: NOAA, National Weather Service)



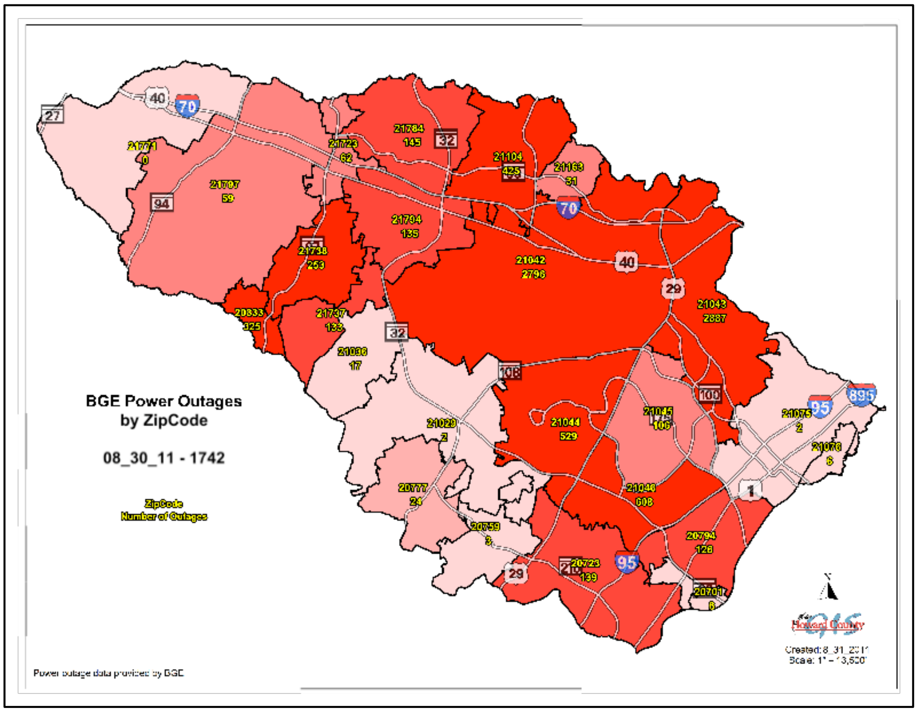
The below figure shows wind speeds across the majority of Howard County averaged 40-45 mph during the storm.

Hurricane Irene: Wind Speeds for Maryland
(Source: NOAA, National Weather Service)



Hurricane Irene also caused widespread power outages throughout the impacted area. The figure below provides a Baltimore Gas and Electric (BGE) report showing the number of power outages on August 30th by Zone Improvement Plan (ZIP) code.

Howard County Power Outages as of August 30, 2011
(Source: Baltimore Gas and Electric, Howard County GIS)



September 7th, 2011 – Tropical Storm Lee

Tropical Storm Lee made landfall on September 4th, 2011 along the Gulf Coast near South-Central Louisiana as a slow-moving storm with heavy rains and winds of 45 mph. The storm slowly moved inland, bringing torrential rain and flooding to the Gulf Coast region. The storm continued inland, tracking towards the Mid-Atlantic and Northeast.

On September 7th, 2011, the remnants of the storm reached the Maryland area. That afternoon, the combination of a warm front moving across the area and the moisture from the remnants of Tropical Storm Lee produced heavy storms and flooding. With two to three inches of rain falling on already saturated soils, the heavy rains caused flash flooding throughout Maryland. Specific to Howard County, flash flood warnings were issued after heavy rains caused numerous rivers and creeks to rise. According the NWS, the Little Patuxent River near Savage rose to 13.6 feet on September 7th, its highest level in the previous five years.[283] [284]

[283] Lindsey McPherson, *Heavy Rains Batter County; Flood Warning Extended to Thursday Morning*, Baltimore Sun, September 7, 2001, available at http://www.baltimoresun.com/explore/howard/news/community/ph-ho-cf-flooding-0915-20110907,0,3036295.story. (last accessed October 4, 2019).
[284] The highest level ever recorded there previously was 18.38 feet in June 1972 after Hurricane Agnes.

The storms and flooding also resulted in numerous road closures. More than 40 road closures were reported in Howard County, including portions of Route 1 and Route 29. South Entrance Road in Columbia, which connects Little Patuxent Parkway to Route 29 Southbound, was closed in the early afternoon of September 7th.

The most significant flooding from Tropical Storm Lee occurred along Main Street in Historic Ellicott City, an area historically prone to flooding. The swollen Patapsco River and Tiber Creek River flooded parts of Main Street. Portions of the road on Main Street were covered in rushing water, causing pockets of water that were several feet deep. Several businesses closest to the river and creek flooded, with up to six feet of floodwater in their basements.[285] As a result of the flooding, the DFRS evacuated the area from the County line to Cocoa Lane (the 8200 through 8500 blocks). The figures below show flooding along Main Street, as well as behind a municipal parking lot adjacent to Main Street.

Flooding in the Valley Mede Subdivision

(Source: Howard County Office of Emergency Management)

Tropical Storm Lee: Flooding Along Main Street Ellicott City

(Source: Elkridge Patch)

[285] *Maryland Historical District: Ellicott City Flooding From Tropical Storm Lee*, http://www.mdhistoricdistrict.com/ellicott-city-flooding-from-tropical-storm-lee/ (last accessed October 4, 2019).

Tropical Storm Lee: Flooding at a Municipal Parking Lot in Historic Ellicott City
(Source: Baltimore Sun)

As a result of the flooding, a Presidential Disaster Declaration (FEMA DR-4038) was declared on October 5, 2011 for Howard County and several other Maryland counties.

October 29th, 2012 – Hurricane Sandy

Hurricane Sandy impacted the United States, Caribbean and Canada. According to the Tropical Cyclone Report, "The cyclone made landfall as a category 1 hurricane (on the Saffir-Simpson Hurricane Wind Scale) in Jamaica, and as a 100-kt category 3 hurricane in eastern Cuba before quickly weakening to a category

1 hurricane while moving through the central and northwestern Bahamas […] The system strengthened into a hurricane while it moved northeastward, parallel to the coast of the southeastern United States, and reached a secondary peak intensity of 85 kts while it turned northwestward toward the mid-Atlantic states."[286] On October 29th, 2012, Hurricane Sandy made landfall to the north of Maryland, along the coast of Southern New Jersey as a post-tropical cyclone with 70 kt maximum sustained winds.[287]

Sandy was responsible for a total of 147 deaths. Within the United States, there were 72 deaths "making Sandy the deadliest U.S. cyclone outside of the southern states since Agnes (1972)."[288] 48 of those deaths occurred in New York, though none occurred in Howard County. 54 deaths occurred in Haiti, 11 in Cuba, three in the Dominican Republic, two in the Bahamas, two offshore within the Atlantic Ocean, one in Canada, one in Jamaica, and one in Puerto Rico.[289] Additionally, within the United States, at least 650,000 houses were damaged or destroyed and 8.5 million lost power.[290]

The size and intensity of the storm brought heavy rain and high winds to Howard County. A water reclamation plant in Savage experienced a power outage. This caused "20 – 25 million gallons of untreated but rain-diluted human waste to spill into the Little Patuxent River, a branch of one of the Chesapeake Bay's most degraded tributaries."[291] Water contamination became a significant threat to the health and environment of those downstream from the plant. Water mains feeding Howard County from the City of Baltimore failed, and the drinking water supply was limited for a period of one to two weeks.

[286] Eric S. Blake, Todd B. Kimberlain, Robert J. Berg, John P. Cangialosi and John L. Beven II National Hurricane Center . (2013, February 12). Tropical Cyclone Report Hurricane Sandy . Retrieved from https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.
[287] Eric S. Blake, Todd B. Kimberlain, Robert J. Berg, John P. Cangialosi and John L. Beven II National Hurricane Center . (2013, February 12). Tropical Cyclone Report Hurricane Sandy . Retrieved from https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.
[288] Eric S. Blake, Todd B. Kimberlain, Robert J. Berg, John P. Cangialosi and John L. Beven II National Hurricane Center . (2013, February 12). Tropical Cyclone Report Hurricane Sandy . Retrieved from https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.
[289] Eric S. Blake, Todd B. Kimberlain, Robert J. Berg, John P. Cangialosi and John L. Beven II National Hurricane Center . (2013, February 12). Tropical Cyclone Report Hurricane Sandy . Retrieved from https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.
[290] Eric S. Blake, Todd B. Kimberlain, Robert J. Berg, John P. Cangialosi and John L. Beven II National Hurricane Center . (2013, February 12). Tropical Cyclone Report Hurricane Sandy . Retrieved from https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf.
[291] Wheeler, T. B. (2012, October 30). Storm triggers Big Howard Sewage Spill. Retrieved from http://paxriverkeeper.org/wp-content/uploads/2015/02/Storm-triggers-Big-Howard-Sewage-Spill-Oct-2012-Balt-Sun.pdf.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Hurricane/Tropical Cyclone Hazard in Howard County	
Historical Average (time period)	2 events (1950-2019)
Historical Annual Probability	1-10% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	11-30% chance of annual occurrence
Future Likelihood Score	3 (Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

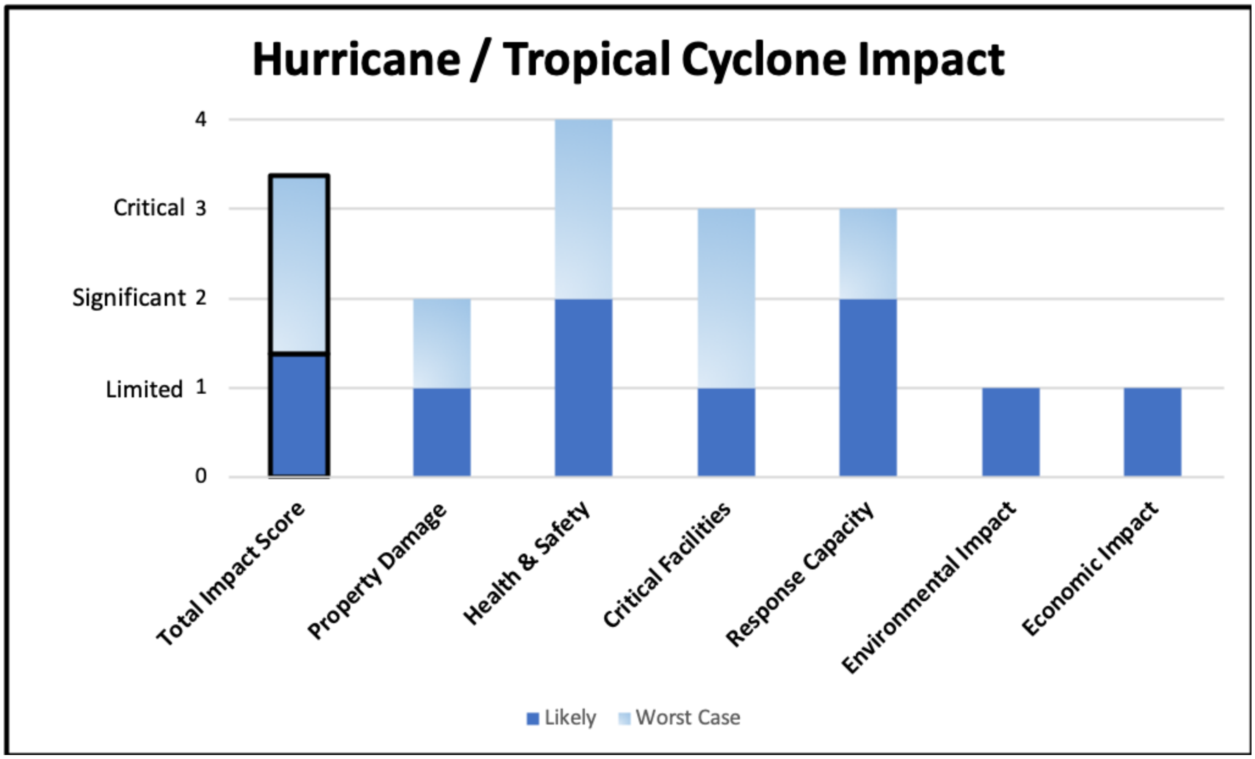
Considerations: The future annual probability of this event is 11-30% chance of annual occurrence, or one event every 3-9 years. An expected increase in rainfall levels and extreme storms may result in a slight increase in the likelihood of flooding.[292] The National Climate Assessment also states that "there has been a substantial increase in most measures of Atlantic hurricane activity since the early 1980s [including] measures of intensity, frequency, and duration as well as the number of strongest (Category 4 and 5) storms."[293] Other considerations include Howard County's proximity to the Chesapeake Bay and its location on the East Coast.

[292] National Climate Assessment. Extreme Weather. Retrieved from https://nca2014.globalchange.gov/highlights/report-findings/extreme-weather. (last accessed October 4, 2019).
[293] National Climate Assessment. Extreme Weather. Retrieved from https://nca2014.globalchange.gov/highlights/report-findings/extreme-weather. (last accessed October 4, 2019).

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Hurricane/Tropical Cyclone Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Very long.* Several days.	*Very long.* Several days.
DURATION	*Moderate.* 24 hours.	*Very Long.* One week.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Hurricanes / Tropical Cyclone Consequence Analysis **Likely**			
CATEGORY	**RANKING**	**DESCRIPTION**	
PROPERTY DAMAGE	*Limited*	▪ Critical and non-critical infrastructure will be damaged. ▪ Ellicott City, Elkridge, and other low-lying areas affected and downed trees and wires with minimal structural damage expected. ▪ Few downed trees and power lines and some flooding across roadways that usually flooded was expected. ▪ Erosion and minor roadbed damage at undersized culverts are expected. ▪ Some structural damage to occupancies and minor flooding is expected.	
HEALTH AND SAFETY	*Significant*	▪ *Health*- Zero deaths expected. Heavy rain and flooding are the most common causes of death. ▪ *Health*- Zero to five injuries expected. Scrapes and cuts from debris are the most common causes of injuries.	
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Hours of critical facilities will be shut down. Trees and branches could cause downed power lines. ▪ *Information/Communication* – Hours-weeks-months of shutdown depending on intensity of damage. ▪ *Transportation* – Road crews shelter in place at height of wind speed will be out of service.	
RESPONSE CAPACITY	*Significant*	▪ *Police* – Local resources adequate. No impact to response capability and continuity of operations. ▪ *Fire and Rescue* – Local resources adequate. Limited impact to response capability. Additional personnel may be required to assist with increased call volume, damage assessment, and Swift Water Team. ▪ *Health* – Local resources adequate. HD operations will not be affected and maintain contact with the EOC. ▪ *Public Works* – Local resources adequate. No impact on response capability and continuity of operations.	
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal impact with short-term spike in water pollution due to flooding. ▪ Limited environmental impact is expected.	
ECONOMIC IMPACT	*Limited*	▪ Limited amount loss in dollar value. ▪ Some infrastructure impact on economic consequences. ▪ Limited economic impact	
TOTAL IMPACT[294]	***Limited - Significant***	▪ **Total Impact Score: 1.375 on a scale of 1 (Limited) to 4 (Catastrophic).**	
Limited	*Significant*	*Critical*	*Catastrophic*

[294] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

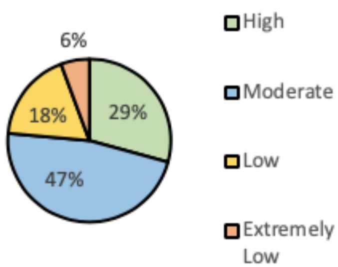
<table>
<tr><th colspan="3">Hurricanes / Tropical Cyclone Consequence Analysis
Worst-Case</th></tr>
<tr><th>CATEGORY</th><th>RANKING</th><th>DESCRIPTION</th></tr>
<tr><td>PROPERTY DAMAGE</td><td>Significant</td><td>▪ Critical and non-critical infrastructure will be damaged.
▪ Ellicott City, Elkridge, and other low-lying areas affected and downed trees and wires with significant structural damage expected.
▪ Structure collapse may be significant in lightweight residential construction, damaged vehicles, etc. is expected.
▪ Major wind damage to a thousand plus homes, water damage in hundreds more homes.</td></tr>
<tr><td>HEALTH AND SAFETY</td><td>Catastrophic</td><td>▪ Zero to two deaths are expected. Heavy rain, flooding, or flying/falling debris is the most common causes of death.
▪ Zero to ten injuries are expected. Lacerations or concussions are the most common causes of injuries.</td></tr>
<tr><td>CRITICAL FACILITIES</td><td>Critical</td><td>▪ <u>Utilities</u> – Critical facilities will be shut down for days/months. Phone and electrical/power facilities will be out of service. Utility = disruption for eighty-thousand (80,000) residents.
▪ <u>Information/Communications</u> – Outages expected. Power disruption for eighty-thousand (80,000) residents.
▪ <u>Transportation</u> – Roads and bridges will be out of service until cleared and repaired.</td></tr>
<tr><td>RESPONSE CAPACITY</td><td>Critical</td><td>▪ <u>Police</u> – Minimal impact to response capability and continuity of operations.
▪ <u>Fire and Rescue</u> – Moderate need for state or federal assistance. Response will be impacted during high winds and post storm.
▪ <u>Health</u> – Moderate need for state or federal assistance. A structural assessment of the HD will determine if the normal operations can be performed there. If the facility is declared unstable, plans are in place to maintain essential functions; virtual operations can be performed for administrative duties.
▪ <u>Public Works</u> – Moderate need for state or federal assistance with no response during low priority items that impact response capability and continuity of operations.</td></tr>
<tr><td>ENVIRONMENTAL IMPACT</td><td>Limited</td><td>▪ Minimal impact on air quality and impacts to land resources will be limited to areas that are affected by flooding.
▪ Old and mature trees can be susceptible to wind throw or windsnap altering the canopy coverage and possible causing erosion or mudslides.</td></tr>
<tr><td>ECONOMIC IMPACT</td><td>Limited</td><td>▪ Downed trees, some structural and roof damage, traffic disruption and limited business closures in economic consequences.
▪ Limited economic impact.</td></tr>
<tr><td>TOTAL IMPACT[295]</td><td>Critical - Catastrophic</td><td>▪ Total Impact Score: 3.375 on a scale of 1 (Limited) to 4 (Catastrophic).</td></tr>
</table>

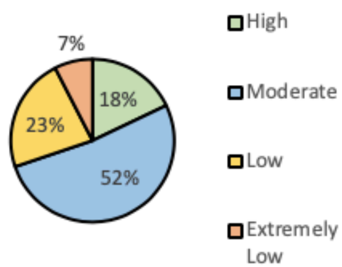
Limited	*Significant*	*Critical*	*Catastrophic*

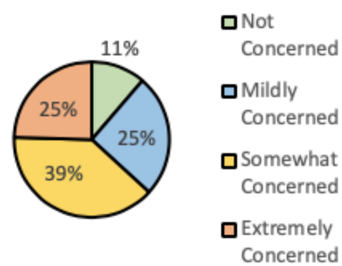
[295] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

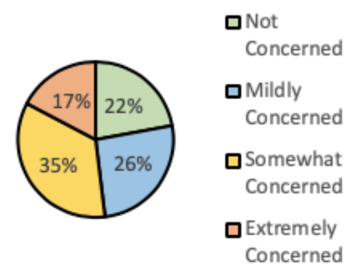
Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

<table>
<tr><th colspan="4">Hurricane / Tropical Cyclone
Public Perception</th></tr>
<tr><th>PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD</th><th>PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD</th><th>CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY</th><th>CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY</th></tr>
<tr>
<td>

Average: 3.00
Moderate</td>
<td>

Average: 2.80
Low - Moderate</td>
<td>

Average: 2.76
Mildly Concerned - Somewhat Concerned</td>
<td>

Average: 2.47
Mildly Concerned - Somewhat Concerned</td>
</tr>
</table>

Lightning

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

Lightning is a giant spark of electricity in the atmosphere between clouds, the air, or the ground. In the early stages of development, air acts as an insulator between the positive and negative charges in the cloud and between the cloud and the ground. When the opposite charges builds up enough, this insulating capacity of the air breaks down and there is a rapid discharge of electricity that we know as lightning. The flash of lightning temporarily equalizes the charged regions in the atmosphere until the opposite charges build up again.

Risk Profile

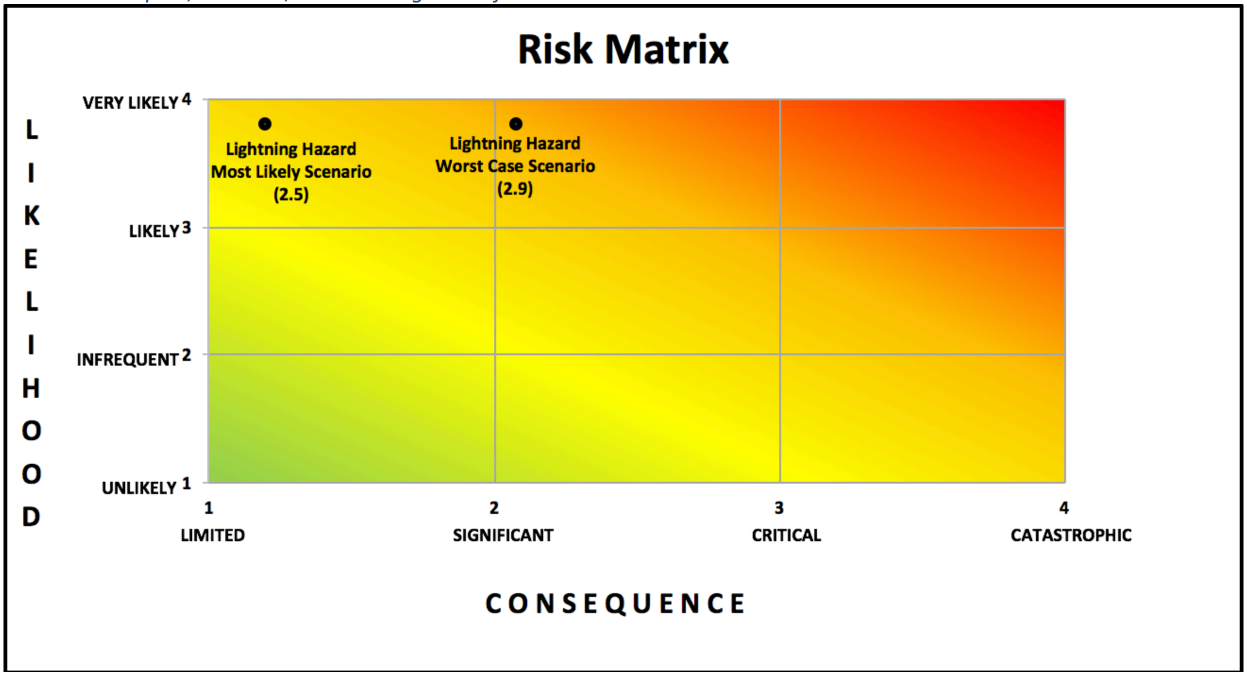
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Lightning Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	3.8 Likely-Very Likely		50%
CONSEQUENCE	**Impact**	1 Limited	2.1 Significant	40%
	Warning Time	3 Moderate	3 Moderate	5%
	Duration	1 Short	1 Short	5%
TOTAL RISK SCORE		**2.5**	**2.9**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

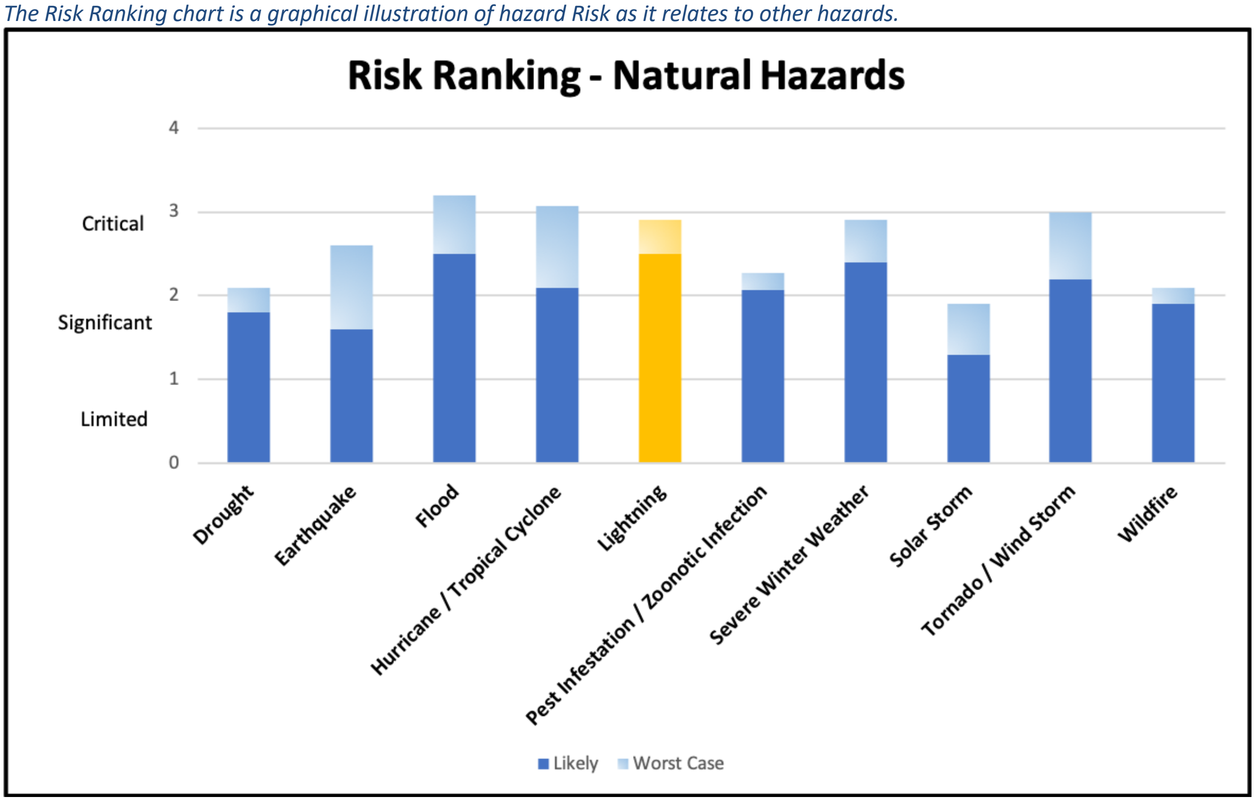
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Lightning events are generated by atmospheric imbalance and turbulence due to a combination of conditions. Lightning, which occurs during all thunderstorms, can strike anywhere. Generated by the buildup of charged ions in a thundercloud, the discharge of a lightning bolt interacts with the best conducting object or surface on the ground. The air in the channel of a lightning strike reaches temperatures higher than 50,000 degrees Fahrenheit.[296]

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Although individual lightning strikes affect a relatively small geographic area, lightning has the potential to affects the entire County equally, particularly during the warmer months of the year. People and property are exposed to damage, injury, and loss of life from lightning in virtually the entire United States. The United States has had 4,136 lightning fatalities from 1959-2017.[297] Of those fatalities, 126 occurred in Maryland, ranking tied for 10th for the greatest number of lightning fatalities within that time period in the United States.[298] In 2018, there were 20 reported lightning fatalities, none of which occurred in Maryland.[299] In 2019, there were 19 reported lightning fatalities in the United States.[300] According to these numbers, there was a total of 4,175 lightning fatalities between 1959-2019. Most lightning-related deaths and injuries occur when people are outdoors during summer afternoons and evenings. Lightning strikes occur when there are thunderstorms. Thunderstorms occur more often in the afternoon and evening "because in order for there to be high amounts of moisture in the air along with warm rising air, there must be instability in the atmosphere. During the warmer months the humidity is much higher."[301]

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[296] For additional information about lightning, see NOAA's *Lightning Safety Tips and Resources*, https://www.weather.gov/safety/lightning (last accessed October 4, 2019). See also generally *NOAA National Weather Service's Glossary*, http://www.weather.gov/glossary/index.php?letter=l (last accessed October 4, 2019).

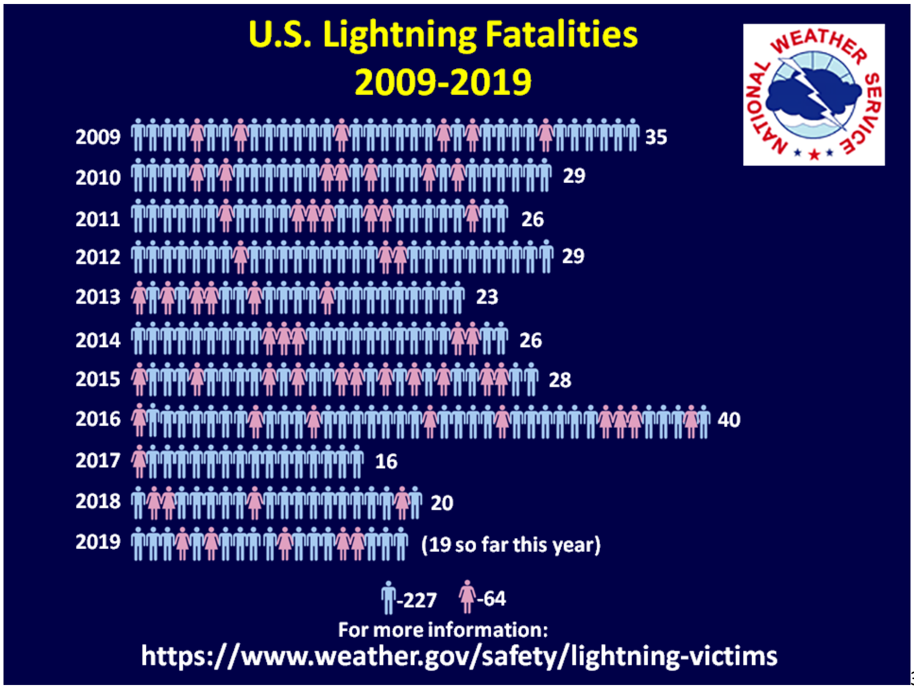
[297] NOAA. Number of Lightning Deaths by State from 1959 to 2017. Retrieved from https://www.weather.gov/media/safety/59-17_State_Ltg_Fatality_Maps_lists.pdf (last accessed October 4, 2019).

[298] NOAA. Number of Lightning Deaths by State from 1959 to 2017. Retrieved from https://www.weather.gov/media/safety/59-17_State_Ltg_Fatality_Maps_lists.pdf (last accessed October 4, 2019).

[299] Facts Statistics: Lightning. (n.d.). Retrieved from https://www.iii.org/fact-statistic/facts-statistics-lightning.

[300] US Department of Commerce, and Noaa. (2019, October 2). National Weather Service Lightning Fatalities in 2019: 19. Retrieved from https://www.weather.gov/safety/lightning-fatalities (last accessed October 4, 2019).

[301] Why Do Thunderstorms Often Occur On Summer Afternoons? (n.d.). Retrieved from https://www.alabamawx.com/?p=196429.



[302]

Between 1995 and 2019, the NCDC did not identify any injuries or deaths in Howard County resulting from lighting strikes. However, there were reports of property damage. The total property damage from lightning strikes when accounting for inflation within this time period was estimated at $1.3 million.[303] Those numbers provided by the NCDC are broken up in the table below.

Year	Damages Reported
1996	$122,637[304]
2000	$148,988[305]
2001	$144,948[306]

[302] US Department of Commerce, and Noaa. (2019, October 2). National Weather Service Lightning Fatalities in 2019: 19. Retrieved from https://www.weather.gov/safety/lightning-fatalities (last accessed October 4, 2019).
[303] NCDC. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(C)+LightningandbeginDate_mm=06andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=04andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 4, 2019).
[304] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 1996 was $75,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[305] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2000 was $100,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[306] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2001 was $100,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

Year	Damages Reported
2002	$713,057[307]
2004	$74,699[308]
2006	$127,260[309]

307 The figure has been adjusted for inflation and is provided in 2019 dollars. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
308 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2004 was $55,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
309 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2006 was $100,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

The NCDC database identified six lightning events in Howard County between 1950 and 2019. Like other hazards, the list appears to only account for events from 1950 onwards. The six events in the database listed occurred between 1994 and 2006. This indicates additional events outside this period are unlikely captured in the database. Although many more lightning events may have occurred, they were not reported to the NCDC. The table below summarizes the significant lighting events that have occurred in Howard County between 1994 and 2019.

Lighting Events, Howard County, 1994 – October 2019
(Source: NOAA/NCDC)

Event ID	Location	Date	Event Type	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
5568044	COLUMBIA	7/8/1996	Lightning	0	0	$122,637[310]	0
5173739	COLUMBIA	8/7/2000	Lightning	0	0	$148,988[311]	0
5265439	CLARKSVILLE	8/11/2001	Lightning	0	0	$144,948[312]	0
5314399	CLARKSVILLE	8/3/2002	Lightning	0	0	$713,057[313]	0
5421712	HANOVER	8/10/2004	Lightning	0	0	$74,699[314]	0
5515110	ELLICOTT CITY	6/1/2006	Lightning	0	0	$127,260[315]	0

310 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 1996 was $75,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
311 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2000 was $100,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
312 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2001 was $100,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
313 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2002 was $500,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
314 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2004 was $55,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
315 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2006 was $100,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

Notable Incidents in Howard County

August 3rd, 2002 - The event that caused the most property damage occurred on August 3rd, 2002, when a lightning strike destroyed a home in Clarksville along Talon Court. This event caused approximately $708,294[316] in property damage. Based on historical data, the future probability of lightning strikes is reasonably high with a severe strike impacting the planning area every couple of years. However, the damage associated with these events is usually minor and not widespread.

July 2019 - In July of 2019 shortly after 2:00 p.m., a man was seriously injured by lightning strike on the Howard County/Baltimore County line while hiking in the Patapsco Valley State Park.[317] That same day, a lightning strike caused damage to a home.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Lightning in Howard County	
Historical Average (time period)	6 events (1994- 2019)
Historical Annual Probability	11-30% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	11-30%+ chance of annual occurrence
Future Likelihood Score[73]	3.875 (Likely- Very Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

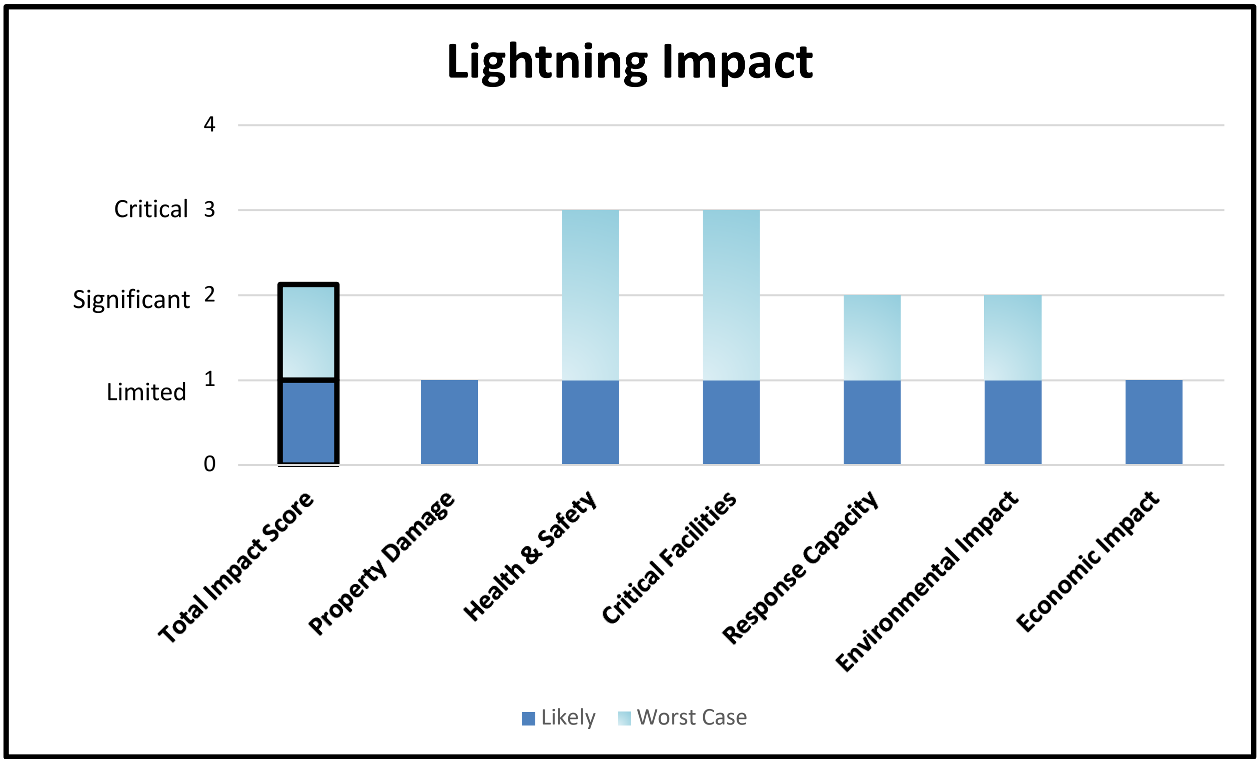
Considerations: The future likelihood of Lightning has increased from the historical average from likely, to very likely. The future probability of Lightning is 11-30%+ chance of annual occurrence or, one event every 3-9 years. This is partially because subject matter experts have deemed that patterns of storms are changing, storms are occurring more frequently, and are more intense.

[316] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $602,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[317] Baltimore lightning injures 1, causes home damage. (2019, July 5). Retrieved from https://wtop.com/baltimore/2019/07/lighting-strikes-in-baltimore-injure-one-cause-home-damage/ (last accessed October 4, 2019).

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Lightning Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Moderate.* Six Hours.	*Moderate.* Six Hours.
DURATION	*Short.* 10 Minutes.	*Short.* 15 minutes.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Lightning Consequence Analysis Likely		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ Up to 0.2% of critical and non-critical infrastructure will be damaged. ▪ Some electrical equipment and panel boxes burned, and some structural issues related to fires caused by lightning expected. ▪ Damaged trees and some traffic signals are expected. ▪ Electrical surge damage will be expected. ▪ Possible fires and possible damage to trees and structures are expected.
HEALTH AND SAFETY	*Limited*	▪ Zero to three deaths are expected depending on the time of year. Electrocution is the most common cause of death. ▪ Zero to ten injuries are expected. Electrical shock, burns, or seizures are the most common causes of injuries.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Shutdown or interruption of service is unlikely. ▪ *Information/Communications* – Shutdown or out of service is unlikely. Localized power outages. ▪ *Transportation* – Shutdown unlikely.
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. No impact to response capability or continuity of operations. ▪ *Fire and Rescue* – Local resources adequate. Limited impact to response capability and continuity of operations. There may be additional small wildfire and limited structure fires as a result of lightning strikes. ▪ *Health* – Local resources adequate. Clinical and administrative operations can be performed normally as long as the auxiliary power is properly maintained or will be moved to another location. ▪ *Public Works* – Local resources adequate. Minor impact on the response capability and continuity of operations.
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal impact. ▪ Could cause loss of canopy coverage or start a forest fire.
ECONOMIC IMPACT	*Limited*	▪ Limited amount loss in dollar value. ▪ Limited economic consequences.
TOTAL IMPACT[318]	***Limited***	▪ **Total Impact Score: 1 on a scale of 1 (Limited) to 4 (Catastrophic).**
Limited	*Significant*	*Critical* / *Catastrophic*

[318] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

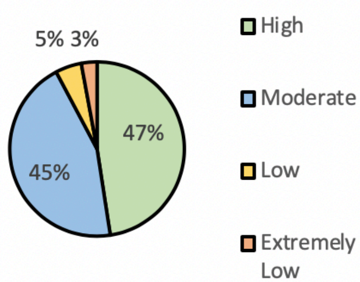
Lightning Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ Critical and non-critical infrastructure will be damaged. ▪ Damage to buildings, electronics, and vegetation. ▪ Lighting strikes cause structure fire and power outages due to lightning strike on electrical grid equipment. ▪ Some electrical equipment and panel boxes burned expected. ▪ Some structural issues related to fires caused by lightning. ▪ Damaged trees and some traffic signals are expected. ▪ Damage to trees, occupancies, falling trees, and limbs are expected.
HEALTH AND SAFETY	*Critical*	▪ Two to five deaths are expected. Electrocution is the most common cause of death. ▪ 10-15 injuries are expected. Electrical shock, burns, or seizures are the most common cause of injuries.
CRITICAL FACILITIES	*Critical*	▪ *Utilities* – Electrically powered facilities will be out of service temporarily. ▪ *Information/Communications* – No shut down or out of service is expected. ▪ *Transportation* – Shut down and out of service is unlikely.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Local resources adequate. No impact on response capability or continuity of operations. ▪ *Fire and Rescue* – Mutual aid needed. Limited impact to response capability, but mutual aid may be needed for fires. There are additional structure fires and wildfires caused by lightning strikes. ▪ *Health* – Mutual aid needed. Clinical and administrative operations can be performed normally as long as the auxiliary power is properly maintained or will be moved to another location. HDOC would be open and communicating with the EOC. ▪ *Public Works* – Local resources adequate. Minor impact on response capability and continuity of operation.
ENVIRONMENTAL IMPACT	*Significant*	▪ Minimal impact but could cause loss of canopy coverage. ▪ There are reports of a wildfire within the park area.
ECONOMIC IMPACT	*Limited*	▪ Transportation impacts in economic consequences. ▪ Limited economic impact.
TOTAL IMPACT[319]	***Significant***	▪ **Total Impact Score: 2.125 on a scale of 1 (Limited) to 4 (Catastrophic).**

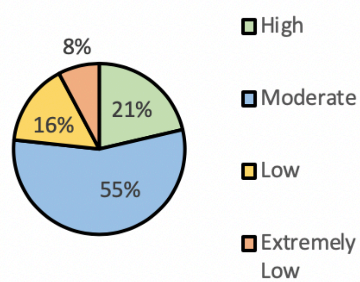
Limited	Significant	Critical	Catastrophic

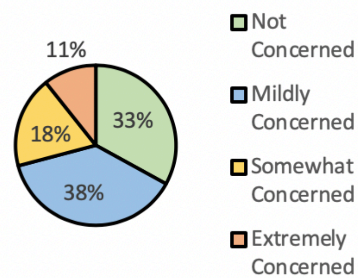
[319] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

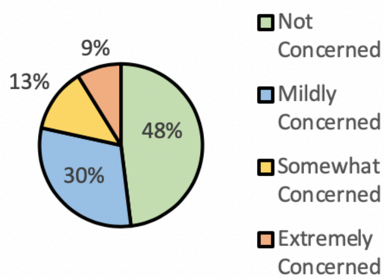
Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

<table>
<tr><th colspan="4">Lightning
Public Perception</th></tr>
<tr><th>PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD</th><th>PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD</th><th>CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY</th><th>CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY</th></tr>
<tr>
<td>

Average: 3.37
Moderate - High</td>
<td>

Average: 2.90
Low - Moderate</td>
<td>

Average: 2.07
Mildly Concerned - Somewhat Concerned</td>
<td>

Average: 1.82
Not Concerned - Mildly Concerned</td>
</tr>
</table>

Pest Infestation/Zoonotic Infection

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

Pest infestation is the occurrence of one or more pest species in an area or location where their numbers and impact are currently or potentially at intolerable levels. Zoonotic Diseases (also known as zoonoses) "are caused by infections that spread between animals and people."[320] Additionally, "Scientists estimate that more than six out of every ten known infectious diseases in people are spread from animals, and three out of every four new or emerging infectious diseases in people are spread from animals. Every year, tens of thousands of Americans will get sick from harmful germs spread between animals and people."[321]

[320] Zoonotic Diseases | One Health | CDC. (n.d.). Retrieved from https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html (last accessed September 27, 2019).
[321] Zoonotic Diseases | One Health | CDC. (n.d.). Retrieved from https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html (last accessed September 27, 2019).

Risk Profile

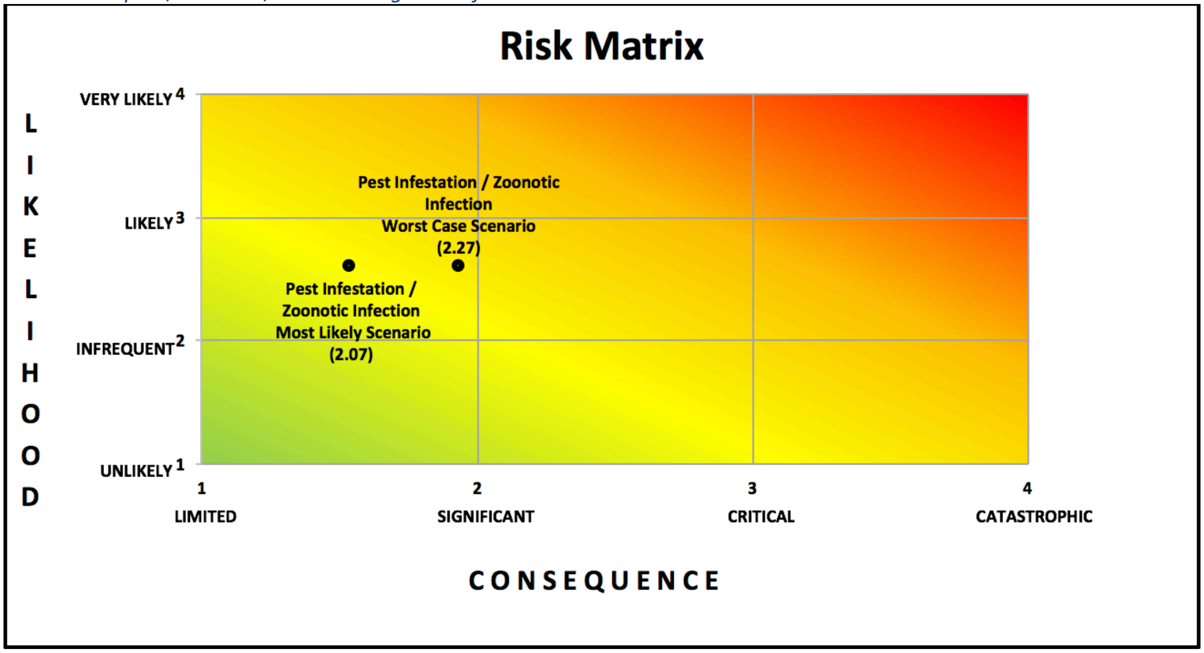
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Pest Infestation/Zoonotic Infection Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	2.6 Infrequent-Likely		50%
CONSEQUENCE	**Impact**	1.3 Limited-Significant	1.8 Limited-Significant	40%
	Warning Time	1 Very Long	1 Very Long	5%
	Duration	4 Very Long	4 Very Long	5%
TOTAL RISK SCORE		**2.07**	**2.27**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

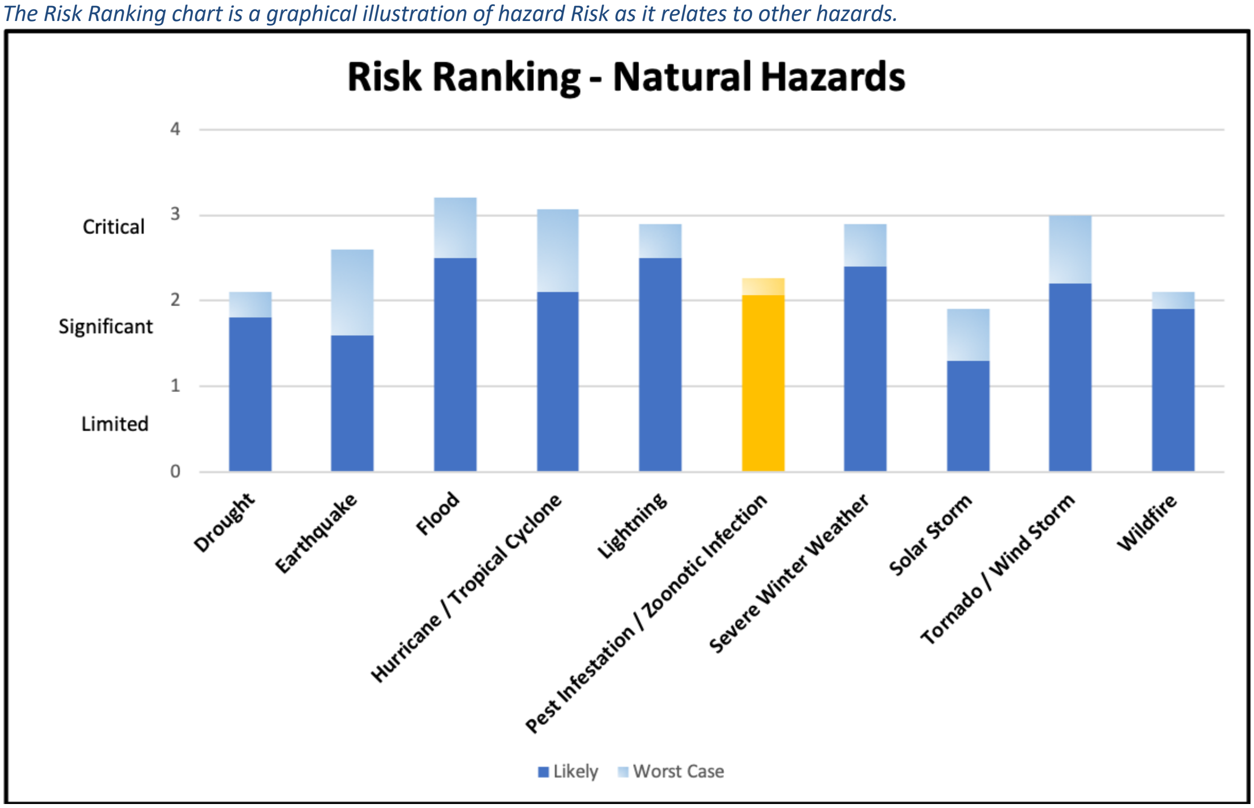
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

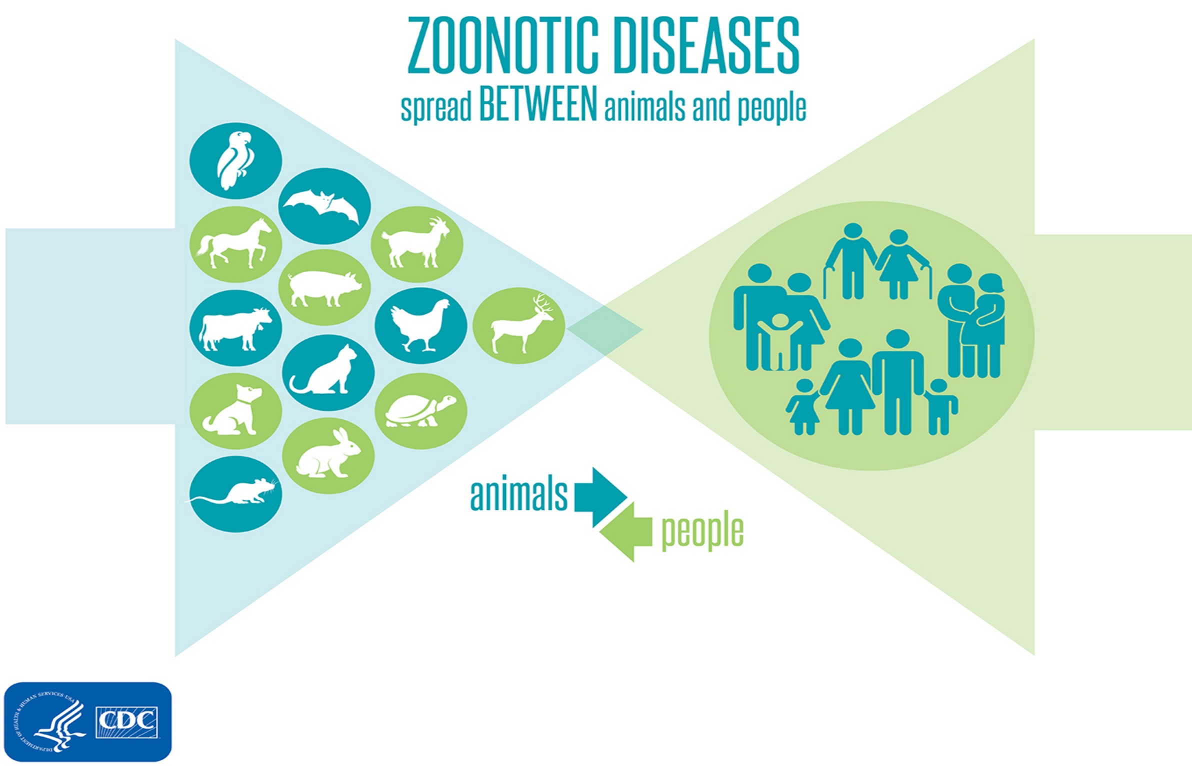
II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Pest infestations include vectors such as insects, birds, and rodents. Two species of bedbugs feed on humans: the common bedbug (*Cimex lectularius*), which occurs in most parts of the world, and the tropical bedbug (*Cimex hemipterus*), which occurs mainly in tropical countries. They are a severe nuisance when they occur in large densities, being commonest in places with poor housing conditions. They are not important in the transmission of diseases, although they possibly play a role as vectors of Hepatitis B virus. For infants living in heavily infested houses, where they may receive 100 or more bites a night, it is possible that the blood loss could cause mild anemia.

Zoonotic Diseases spread between animals and people. Some examples of Zoonotic diseases / infections include, but are not limited to, animal influenza, avian influenza, and Lyme disease.[322]



323

322 List of zoonotic diseases. (n.d.). Retrieved from https://www.gov.uk/government/publications/list-of-zoonotic-diseases/list-of-zoonotic-diseases.
323 CDC. (n.d.). Zoonotic Diseases. Retrieved from https://www.cdc.gov/onehealth/images/zoonotic-diseases-spread-between-animals-and-people.jpg.

Zika is a viral disease transmitted to humans by infected mosquitoes. It causes fever and severe joint pain. Other symptoms include muscle pain, headache, nausea, fatigue and rash. After the bite of an infected mosquito, onset of illness occurs usually between four to eight days but can range from two to 12 days. The Zika virus was first identified in 1947 in Uganda. This virus produced a rare and mild disease until suddenly re-emerged in Brazil in 2015 and spread explosively through South America, Central America, and the Caribbean. The first importation in the United States may have occurred between March and mid-April of 2016, however, it was not detected until July 2016.[324] The Zika virus is associated with a birth defect known as microcephaly. In addition, the Zika virus can cause a neurologic condition, known as Guillain-Barre Syndrome, in adults which results in muscle weakness or paralysis, in extreme cases.

These viruses are transmitted from human-to-human by the bites of infected female mosquitoes. Most commonly, the mosquitoes involved are *Aedes aegypti* and *Aedes albopictus*, two species which can also transmit other mosquito-borne viruses, including West Nile Virus and dengue. These mosquitoes can be found biting throughout daylight hours, though there may be peaks of activity in the early morning and late afternoon. Both species are found biting outdoors, but *Aedes aegypti* will also readily feed indoors.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Between 2015 and 2018[325] the Health Department received about four to six cockroach complaints each year, about 30-40 rodent complaints each year, and about 25-30 mosquito complaints each year. Most of these complaints were localized and do not reflect a widespread "infestation". The Howard County Health Department (HCHD) receives about 700 rabies exposure cases reported per year, and about 10-12 animals that test positive for rabies. Every so often, the HCHD has an increase in animals testing positive for rabies. Generally, racoons are the most prevalent rabies vector in Howard County. However, a fair number of bats and cats contributed to those overall numbers.

Pest infestations can be short term or extend for indefinite periods of time. In the past 10 years there has been a resurgence of bedbug infestations. The Maryland Department of Health (MDH) issued a notification on November 10, 2008 stating over the course of the previous six months, there had been an increase in bedbug investigations in Maryland, which was consistent with increasing national reports. As of June 2019, bedbug infestations are still being reported. Low, but persistent levels of West Nile Virus and more recently (to a lesser extent), Zika Virus, are examples of mosquito related pest infestations that have been documented throughout Maryland, including Howard County. Similar to West Nile Virus, Zika has the potential to affect citizens and visitors to Howard County who have spent time in areas with an

[324] Marini, G., Guzzetta, G., Rosà, R., & Merler, S. (2017). First outbreak of Zika virus in the continental United States: a modelling analysis. *Euro surveillance : bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin*, *22*(37), 30612. doi:10.2807/1560-7917.ES.2017.22.37.30612

[325] This was the most up to date information provided by Subject Matter Experts at the time of the creation of the HIRA. At the time data was collected, 2019 information was not available.

infected mosquito population. Pregnant women may be the most vulnerable as cases of microcephaly have been linked with fetuses exposed in utero to the Zika virus. Lyme Disease, a tickborne related disease, is also well documented in Howard County.

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

Notable Incidents in Howard County

There are no notable incidents in Howard County during the review period of 1964-2019.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

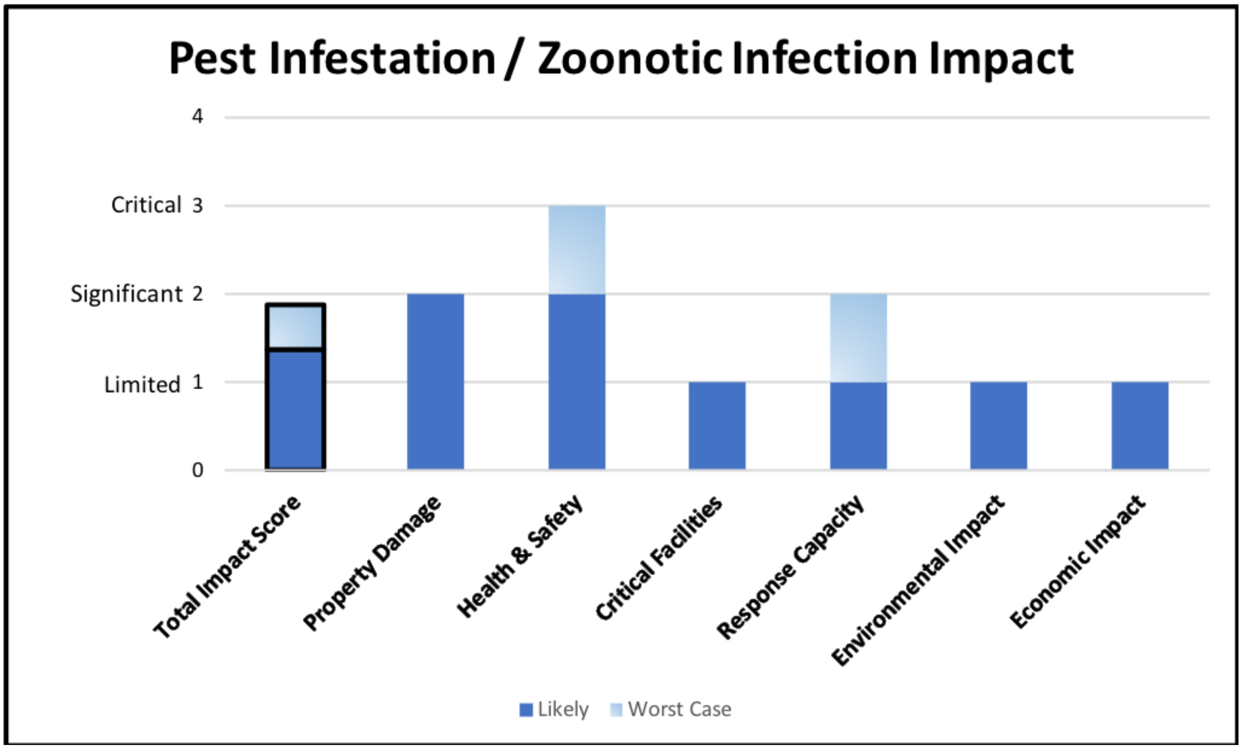
Future Likelihood of a Pest Infestation/Zoonotic Infection in Howard County	
Historical Average (time period)	Zero events (1964-2019)
Historical Annual Probability	0% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	Yes
Future Annual Probability	1-30% chance of annual occurrence
Future Likelihood Score	2.6 (Infrequent- Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: Howard County has the appropriate climate for many insects with infectious characteristics. Additionally, there is frequent travel within the County and many bed bug cases occur in hotels. Howard County is near many metro areas/airports/and interstates which increases the likelihood of diseases being spread across the County. The future annual probability for this hazard is 1-30% chance of annual occurrence, or, one event every 9-99 years.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Pest Infestation/Zoonotic Infection Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Very Long.* More than 24 hours.	*Very Long.* Two weeks to a month.
DURATION	*Very Long.* Several days to two weeks to fully exterminate.	*Very Long.* Seasonal- spring to fall.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Pest Infestation / Zoonotic Infection Consequence Analysis **Likely**				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Significant*	▪ 0.5% of critical and non-critical infrastructure will be damaged. ▪ No structural damage but significant loss in furniture and carpeting is expected.		
HEALTH AND SAFETY	*Significant*	▪ Zero deaths are expected. Most deaths would be unlikely but when they do occur, it is due to an occurrence in conjunction with other comorbidities. ▪ Zero to five injuries are expected. Allergy, anxiety, and sleepiness are the most common causes of injuries. ▪ While bed bugs are not important in the transmission of diseases, they possibly play a role as vectors of hepatitis B virus. ▪ In heavily infested houses where people may receive one hundred or more bites a night it is possible that the blood loss causes mild anemia in infants		
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – No critical facilities will be shut down and no outage is expected. ▪ *Information/Communications* – Shutdown unlikely. No major impact on information or communications infrastructure. ▪ *Transportation* – Shutdown unlikely. Impacts to transportation will be minor and short-term.		
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. No impact to response capability or continuity of operations. ▪ *Fire and Rescue* –Local resources adequate. No impact to response capability and continuity of operations. ▪ *Health* – Local resources adequate. HD operations will not be affected. The HDOC will be monitoring and recording infestations throughout the county with the assistance of Environmental Health. Informing the public and steps needed to ensure to maintain a healthy living environment will occur. ▪ *Public Works* – Local resources adequate. No impact on response capability and continuity of operations.		
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact is expected. Minimal impact on air, water, and land resources.		
ECONOMIC IMPACT	*Limited*	▪ Limited economic impact. Negative impact on retail and County reputation in economic consequences.		
TOTAL IMPACT[326]	***Limited-Significant***	▪ **Total Impact Score: 1.375 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

[326] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

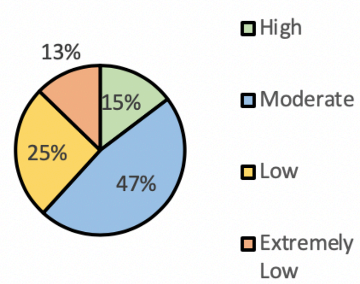
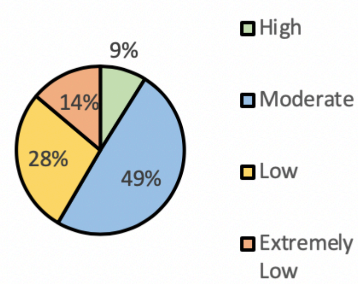
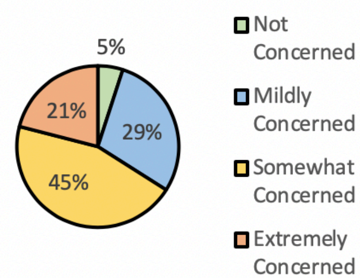
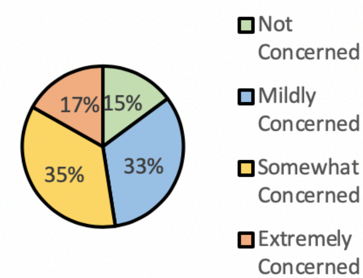
Pest Infestation/Zoonotic Infection Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Significant*	▪ 0.5% of critical and non-critical infrastructure will be damaged. ▪ No structural damage but significant loss in furniture and carpeting is expected.
HEALTH AND SAFETY	*Critical*	▪ Zero to two deaths are expected. ▪ Four pregnant women are infected and thirty (30) are infected but are asymptomatic. Injuries include fever, severe joint pain, muscle pain, headache, nausea, fatigue and rash. Zika virus can cause a neurologic condition in adults known as Guillain-Barre syndrome that results in muscle weakness or paralysis in most extreme cases.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – No critical facilities will be shut down and no outage is expected. ▪ *Information/Communications* – No shutdown. No major impact on information or communications infrastructure. ▪ *Transportation* – Shutdown unlikely. Impacts to transportation will be minor and short-term.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Local resources adequate. No impact to response capability or continuity of operations. ▪ *Fire and Rescue* – Local resources adequate. ▪ *Health* – Moderate need for state or federal assistance. HD operations will not be affected. The HDOC will be monitoring and recording cases of Zika throughout the county with the assistance of Environmental Health. Informing the public and steps needed to ensure to maintain a healthy living environment will occur. ▪ *Public Works* – Local resources adequate.
ENVIRONMENTAL IMPACT	*Limited*	▪ Limited environmental impact is expected.
ECONOMIC IMPACT	*Limited*	▪ Limited economic impact.
TOTAL IMPACT[327]	***Limited - Significant***	▪ **Total Impact Score: 1.875 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	Significant	Critical	Catastrophic

[327] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health / safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Pest Infestation / Zoonotic Infection Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
 *Average: 2.64 Low - Moderate*	 *Average: 2.53 Low - Moderate*	 *Average: 2.82 Mildly Concerned - Somewhat Concerned*	 *Average: 2.54 Mildly Concerned - Somewhat Concerned*

Severe Winter Weather

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

Severe Winter Weather refers to a weather event that produces forms of precipitation caused by cold temperatures, such as snow, sleet, ice, and freezing rain, while ground temperatures are cold enough to cause precipitation to freeze. Windy conditions may also be present during a winter weather event.

Risk Profile

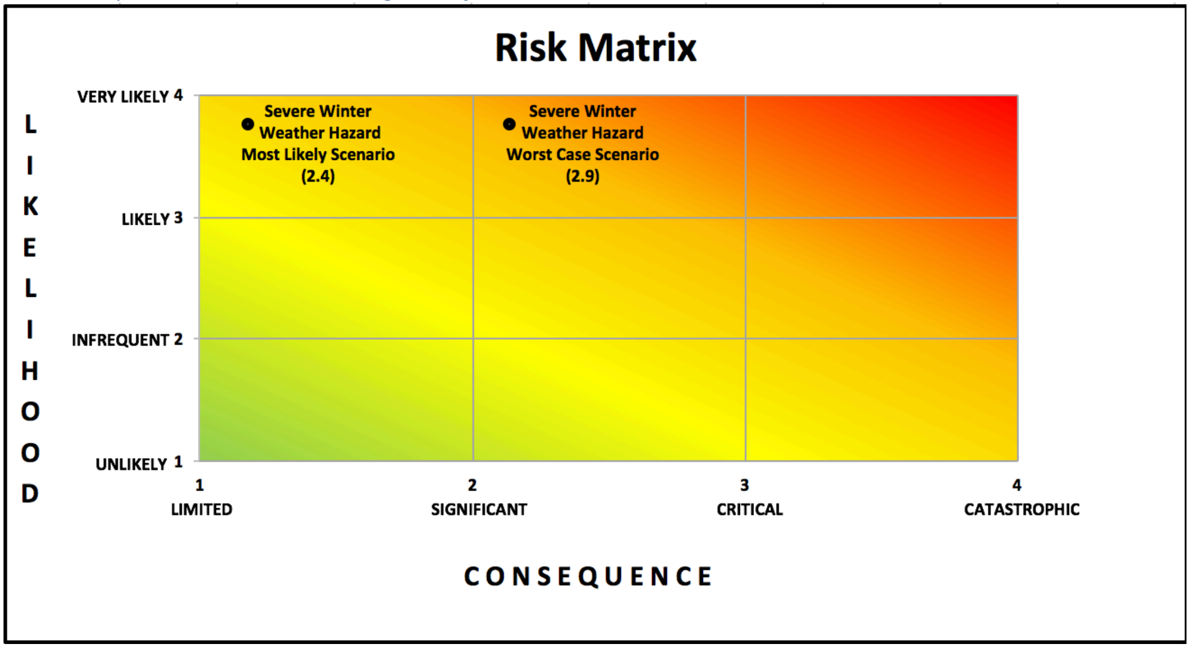
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Severe Winter Weather Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	3.75 Likely-Very Likely		50%
CONSEQUENCE	**Impact**	1.1 Limited	2.3 Significant-Critical	40%
	Warning Time	2 Long	1 Very Long	5%
	Duration	1 Short	2 Moderate	5%
TOTAL RISK SCORE		**2.4**	**2.9**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

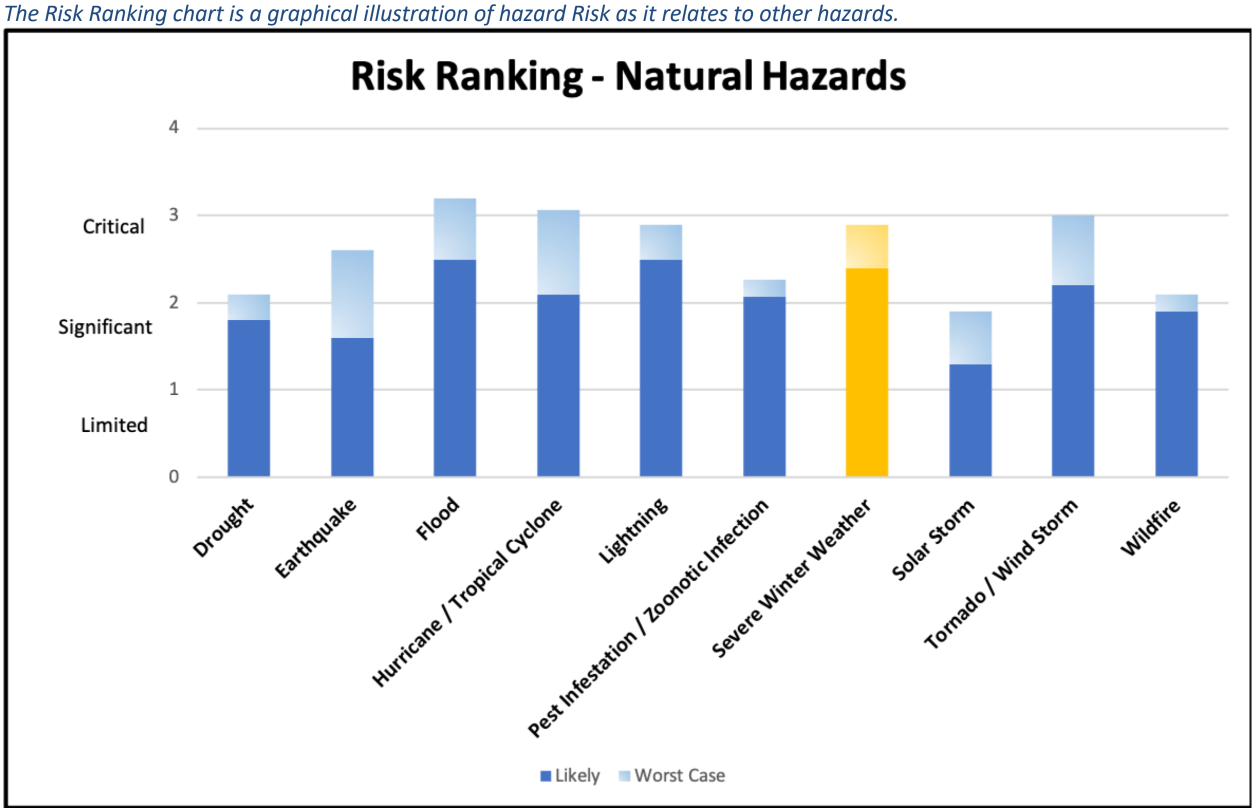
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Severe winter weather refers to a weather event that produces forms of precipitation caused by cold temperatures, such as snow, sleet, ice, and freezing rain, while ground temperatures are cold enough to cause precipitation to freeze. Windy conditions may also be present during a winter weather event. The accumulation of these forms of precipitation can immobilize the entire region, leaving roads impassable, triggering utility outages, causing flooding and storm surge, and may lead to the loss of lives. These impacts may be enhanced with the presence of windy conditions, which can lead to blizzard, whiteout conditions, and drifting of snow.[328] Additionally, these conditions have the potential to cause transportation hazards.

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Severe Winter Weather, including snowstorms, ice storms, and extreme cold, may affect any part of Howard County during winter. The annual snowfall for the County is approximately 24 inches, which is relatively moderate.[329] Within Howard County, the risk to people and property from winter weather cannot be distinguished by area because of its central location.

The particular vulnerabilities for Howard County include the prevalence of old buildings with roof structures that are not up to current standards. There are also many barns in Howard County which do not require permits and thus may be more vulnerable to damage from winter weather events.

Winter weather events occur on a yearly basis in the County, but significant improvements to building codes, maintenance to structures, and weather forecasting has dramatically decreased the threat to people and property. Even with these improvements, a risk of injury or death to individuals during a winter event may still exist, particularly with elderly persons, small children, infants and/or the chronically ill. These groups may be more susceptible and vulnerable to injury or death if they are exposed to the winter weather event or if they do not have adequate heating in their homes. Also, heavy snow loads on roofs may cause structural failure or structural damage to buildings and infrastructure.

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[328] For additional information about winter storms, see NOAA's *Weather Prediction Center*, https://www.wpc.ncep.noaa.gov/#page=ovw (last accessed September 27, 2019). See also *Winter Weather Basics*, https://www.nssl.noaa.gov/education/svrwx101/winter/ (last accessed September 26, 2019).

[329] Climate and Geography. Retrieved from http://www.hceda.org/why-howard-county/living/climate-geography/ (last accessed October 8, 2019).

Severe winter weather events could also result in increased traffic accidents, impassable roads, and loss of income. On roadways, snow and ice can reduce visibility and affect automobile traction as bridges may freeze prior to the majority of the roadways. It is important to note that this is not the only cause for this occurrence. Disruption of roadways and other transportation methods is a threat to the County's economic well-being because individuals may not be able to travel to work and the shipment of goods could come to a standstill.

County residents may also be affected physically by severe winter weather events. Individuals may injure themselves while walking on ice and snow or suffer heart attacks as a result from overexertion from shoveling snow. Although rare, carbon monoxide poisoning can occur during winter weather events when heaters, automobile mufflers, or generators are not vented properly.[330] Frostbite and hypothermia may also lead to death or injury.

[330] In Ellicott City, one died and two were seriously injured from carbon monoxide poisoning when a family used a generator indoors during Hurricane Irene's wake. See *Two Improving in Ellicott City Carbon Monoxide Poisoning that Left One Dead*, http://www.baltimoresun.com/explore/howard/news/ph-ho-cf-co-poisoning-0901-20110830,0,3266348.story (last accessed September 27, 2019).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

Counties in Western Maryland experience significantly more annual snowfall, while counties closer to Maryland's Eastern Shore generally have a smaller annual snowfall total. According to the Maryland State Climatologist Office, "average annual snowfall over Maryland ranges from a minimum of 8-10 inches along the coastal areas of the Southern Eastern Shore division to a maximum well over 80 inches in Garrett County."[331] Generally, the winter storm season for the eastern portion of Maryland runs from November to mid-March, while the western counties experience longer winters. Severe winter weather has occurred as early as October and as late as May in eastern portions of the State.

The NCDC database reports Howard County has experienced 14 winter storm events between 2015 and 2019.[332] Additionally, the NCDC database separately categorized 72 winter weather events[333]; two blizzards both occurring in 2016[334]; six cold/wind chill events[335]; and 20 freeze events[336] since 1950. It is important to note the data reflected between the 1950 and October 2019 period has its first report of these hazards in 2014. Data from the NOAA/NCDC database is derived from a number of sources but may not be the most exhaustive resource for consequence figures. At the time of the search, the NOAA/NCDC

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331 Maryland State Climatologist Office. Maryland's Climate. Retrieved from https://www.atmos.umd.edu/~climate/ClimateInfo/mdClimate.php (last accessed October 8, 2019).

332 NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=%28Z%29+Winter+StormandbeginDate_mm=01andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=08andendDate_yyyy=2019andcounty=HOWARD%3A27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24%2CMARYLAND (last accessed October 8, 2019).

333 NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(Z)+Winter+WeatherandbeginDate_mm=06andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=08andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 8, 2019).

334 NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(Z)+BlizzardandbeginDate_mm=06andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=08andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 8, 2019).

335 NOAA. (n.d.). Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(Z)+Cold/Wind+ChillandbeginDate_mm=01andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=08andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 8, 2019).

336 NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(Z)+Frost/FreezeandbeginDate_mm=01andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=08andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 8, 2019).

database only contained data through October of 2019. Although not indicated in the NCDC database, the severe winter storms in December 2009 and February 2010 also resulted in property damage. Based on this information, there was an estimated total of 114 severe winter weather events that occurred during the review period of 1950-2019.

Notable Incidents in Howard County

February 1899 - Also known as the "Great Eastern Blizzard of 1899," this February 1899 storm is one of the earliest documented severe winter storm events in the area. The storm produced approximately 20 inches of snow across the region.

January 5th, 1912 – February 12th, 1912 - Known as the "Great Cold Wave" of January 1912, extreme cold was recorded across the region. In Howard County, reports showed that temperatures fell close to 20 degrees below zero and resulted in freeze across the area.

January 27th, 1922 – January 28th, 1922 - Known as the "Knickerbocker Storm," this nor'easter brought between 30-32 inches of snow across the County. Its high winds also brought blizzard and whiteout conditions across the region.

March 29th, 1942 – March 30th, 1942 - The "Palm Sunday Snowstorm" was the heaviest March snowstorm on record in Maryland. The storm dropped over 20 inches of heavy, wet snow in Howard County.

February 18th, 1979 - The "Presidents' Day Storm" brought the second greatest amount of snow fall in Howard County, bringing snow of up to 20 inches over the Northern Virginia and Maryland region. At times, snow was falling two to three inches an hour, and temperatures fell to the single digits.

February 11th, 1983 – February 12th 1983 - The "Blizzard of 1983" was the second greatest snow fall in the region. Over two feet of snow covered the County. During certain periods, snow fell at a rate of 3.5 inches per hour.

January 7th, 1996 – January 13th, 1996 - The "Blizzard of '96'" brought between 18-30 inches of snow to Howard County on January 8th. On the 9th, an "Alberta Clipper" left an additional three to five inches of snow throughout the region. A third storm brought another four to six inches of snow. The County had two to three feet of snow by the end of the week.

January 14th, 1999 - An arctic cold front moved over Central Maryland and brought snow and freezing rain to the region. The snow turned to freezing rain while the ground remained below freezing, which, in turn, created hazardous conditions. Ice accumulations ranged from ¼ to ½ inch with winds gusting over 40 mph, resulting in fallen trees and power outages across the County. At one point, as many as 39,000 households were without power. The Governor of Maryland declared a State of Emergency for Howard County and the surrounding counties.

December 11th, 2000 - A low pressure system produced between one to two inches of rain. However, the rain then turned to ice as temperatures dropped below freezing. In some locations, ice accumulated to ¼ of an inch thick. In Howard County, 22 people were treated for slip and fall injures related to the ice accumulation.

February 2003 - The NCDC database indicates that one of the most severe winter storms resulting in property damage and loss of life occurred on February 14th, 2003 and lasted until February 18th, 2003. The system brought three waves of wintery precipitation to the region. The first line of precipitation started to fall on the evening of the 14th as a mix of light to moderate snow or rain. The next round, on the 16th and 17th, took the form of heavy wet snow and sleet. The event ended with snow showers tapering off on the 18th. When the winter storm ended, snowfall totals ranged from 20 to 32 inches across the Baltimore Metropolitan area. Estimated regional property damages from the storm were $8.5 million[337]. In Howard County, a barn, warehouse, store awning, tennis bubble dome, greenhouse, and shed collapsed under the weight of the snow.

February 11th, 2006 – February 12th, 2006 - Approximately 14-22.5 inches of snow fell across the Washington, D.C. and Baltimore Metropolitan regions, with Howard County suffering a direct hit from the storm. The highest snowfall total occurred in Columbia Hills, which is located in the north-east part of the County. In that region, snowfall of up to 22.5 inches was recorded. There were numerous reports of downed trees and power outages in the County. NCDC database estimated property damage to be $291,789[338] for the entire storm.

February 12th, 2008 - A wintery mix of snow and ice produced roughly an inch of snow and between 0.1-0.3 inches of ice. The central and eastern portions of Maryland saw a quick change from snow to ice, which froze just before the evening commute. As road conditions deteriorated, a number of accidents were reported across the region.

2009-2010 - The 2009-2010 winter season brought the highest snowfall on record in the region. Several waves of severe snow events dropped over a foot of snow each in the County. The first low pressure system arrived on the night of December 18th, 2009. The system strengthened on the 19th, as moisture from the South pushed northward while the cold air remained in place. Snowfall totals ranged from 14-17 inches across the County. As a result of this event, a Presidential Disaster Declaration (DR-1875) was issued for the State of Maryland on February 19th, 2010 for the December storms. Before the Presidential Disaster Declaration was even issued for the December storms, the State was hammered yet again by a line of severe winter storms from February 5th to February 11th, 2010 and produced a snowfall of 10-20 inches across the County. Certain parts of the County had even higher localized amounts. As a result of

[337] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2003 was $6.1 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[338] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $248,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

this event, another statewide Presidential Disaster Declaration (FEMA DR-1910) was declared on May 6th, 2010 for the February storms.

January 26th, 2011 – January 27th, 2011 - A snowfall event produced between eight to thirteen inches of snow across the County. The heavy, wet snow brought trees and power lines down and left thousands without power. Unfortunately, the storm coincided with the evening rush hour which resulted in numerous car accidents and roadway shutdowns. There were also several reports of tractor trailers jackknifing due the slick road conditions.

January 2016 - On January 22, 2016, then County Executive Kittleman declared a State of Emergency in Howard County. The blizzard caused "snow totals ranging from 24 inches near Columbia to more than 30 inches in western parts of the county. Snow drifts in some areas reached five to six feet high."[339] Additionally, the National Guard deployed to the County to complete 56 missions. This storm resulted in a Presidential Disaster Declaration. [340]

The following photos were taken from the Blizzard 2016 Preparation, scenes, and response in Howard County, Maryland Howard County Government page.

[339] Blizzard 2016 by Howard County Government on Exposure. Retrieved from https://hocogov.exposure.co/blizzard-2016 (last accessed October 8, 2019).

[340] Blizzard 2016 by Howard County Government on Exposure. Retrieved from https://hocogov.exposure.co/blizzard-2016 (last accessed October 8, 2019).


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341 Blizzard 2016 by Howard County Government on Exposure. Retrieved from https://hocogov.exposure.co/blizzard-2016 (last accessed October 8, 2019).
342 Blizzard 2016 by Howard County Government on Exposure. Retrieved from https://hocogov.exposure.co/blizzard-2016 (last accessed October 8, 2019).

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Severe Winter Weather in Howard County	
Historical Average (time period)	114 events (2014-2019)
Historical Annual Probability	30%+ chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	11-30%+ chance of annual occurrence
Future Likelihood Score[73]	3.75 (Likely- Very Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

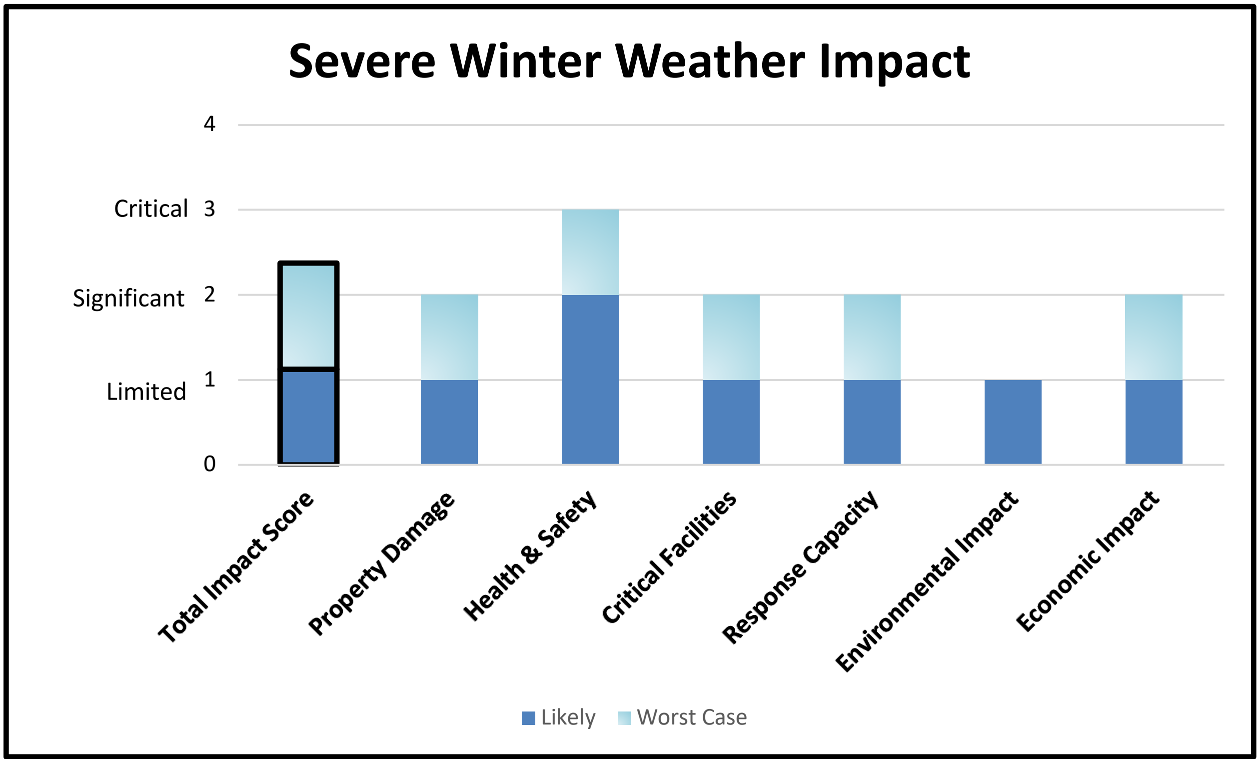
Considerations: The future annual probability of the hazard is 11-30%+ chance of annual occurrence, or, one event every 3-9 years. An expected increase in extreme storms may result in a slight increase in the likelihood of severe winter weather in Howard County.[343] Other considerations include the impact climate change will have on the severity and frequency of these storms.

[343] *Third National Climate Assessment,* U.S. Global Change Research Program (2014). Available at http://nca2014.globalchange.gov/ (last accessed September 27, 2019).

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Severe Winter Weather Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Long.* 24 hours.	*Very Long.* 24-72 hours.
DURATION	*Short.* Three hours.	*Moderate.* 18 hours.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Severe Winter Weather Consequence Analysis Likely		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ Critical and non-critical infrastructure will not be damaged. ▪ No damage anticipated except icing on some roadways and bridges are expected. ▪ Downed power lines, vehicle accidents, and falling tree limbs are expected.
HEALTH AND SAFETY	*Significant*	▪ Zero deaths are expected. Automobile accidents and hypothermia are the most common causes of death. ▪ Zero to five injuries are expected. Automobile accidents and cold weather injuries are the most common cause of injuries.
CRITICAL FACILITIES	*Limited*	▪ *Utilities* – Minor disruption, shutdown unlikely. ▪ *Information/Communications* – minor power disruption, shutdown unlikely. ▪ *Transportation* – Transportation issues will occur and there will be vehicle accidents.
RESPONSE CAPACITY	*Limited*	▪ *Police* – Emergency service disruption however, local resources adequate. No impact to response capability and continuity of operations. ▪ *Fire and Rescue* – Emergency service disruption however, local resources adequate. Limited impact to response capability. Increased call volume for vehicle accidents. ▪ *Health* – Local resources adequate. HD operations will not be affected. ▪ *Public Works* – Local resources adequate. ▪ Government Services –Reduced government services.
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal immediate impact. ▪ Repeated use of road salt impacts water resources. ▪ Increased Chloride levels are harmful to aquatic and human life. ▪ Loss of tree limbs and downed trees are likely.
ECONOMIC IMPACT	*Limited*	▪ Traffic delays impact in economic consequences. ▪ Workforce reduction.
TOTAL IMPACT[344]	***Limited***	▪ **Total Impact Score: 1.125 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[344] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

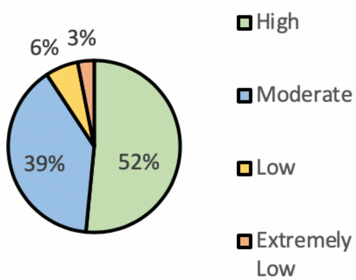
Severe Winter Weather Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Significant*	▪ Critical and non-critical infrastructure will be damaged. ▪ Damage to some curbs, storm drains inlets, and mailboxes are expected. ▪ Some roof and interior flooding after and during melting is expected. ▪ Structure collapse of occupancies is expected.
HEALTH AND SAFETY	*Critical*	▪ Zero to two deaths are expected. Automobiles, loss of power and heat sources, and overexertion from snow removal are the most common causes of death. Zero to 20 injuries are expected. Frost bite, hypothermia, automobile accidents, and overexertion from snow removal are the most common causes of injuries.
CRITICAL FACILITIES	*Significant*	▪ *Utilities* – Up to 18 hours during the storm and during clean-up, critical facilities will be shut down. All above ground facilities may be out of service until clean up. ▪ Information/Communications – Government, electrical, power, and schools will be out of service. Power outages occur across the County and it takes seven to ten days to restore power. ▪ *Transportation* – One to two days shutdown are expected. Government facilities and transit and rails will be out of service.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Moderate need for state or federal assistance. Low impact to response capability and continuity of operations. May require law enforcement to include additional manpower resources and schedule changes to departmental personnel. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state and Federal assistance. Impact will be for personnel and operations. ▪ *Health* – Moderate need for state or federal assistance. HD would monitor Web EOC virtually and be in communication with the EOC. ▪ *Public Works* – Significant and long-lasting need for state or federal assistance. Long working hours for crews with minimal breaks.
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal immediate impact. ▪ Repeated use of road salt is raising the chloride levels in streams and reservoirs. Increased levels of chloride are harmful to aquatic and human life. ▪ Flooding can occur due to the temperature rising and snowfall melting.
ECONOMIC IMPACT	*Significant*	▪ Business closures, loss of productivity, and employment disruption to transportation network are the economic consequences. ▪ Supply chain severely effected in the short term. ▪ Lack of resources such as gasoline and food.
TOTAL IMPACT[345]	***Significant - Critical***	▪ **Total Impact Score: 2.375 on a scale of 1 (Limited) to 4 (Catastrophic).**

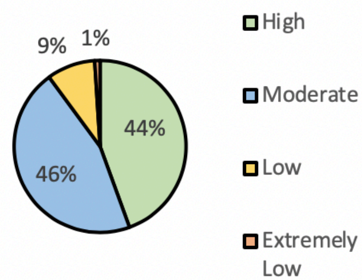
Limited	*Significant*	*Critical*	*Catastrophic*

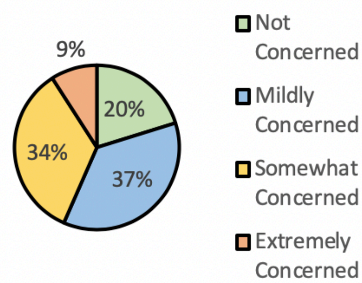
[345] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

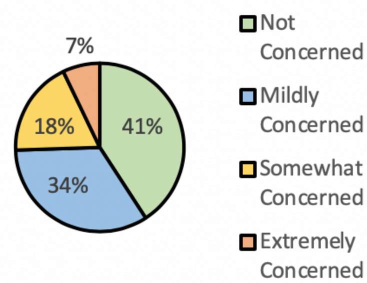
Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

<table>
<tr><th colspan="4">Severe Winter Weather
Public Perception</th></tr>
<tr><th>PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD</th><th>PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD</th><th>CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY</th><th>CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY</th></tr>
<tr>
<td>

Average: 3.39
Moderate - High</td>
<td>

Average: 3.33
Moderate - Hiah</td>
<td>

Average: 2.32
Mildly Concerned - Somewhat Concerned</td>
<td>

Average: 1.92
Not Concerned - Mildly Concerned</td>
</tr>
</table>

Solar Storm Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

Solar Storms, also referred to as geomagnetic storms, are "a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding Earth."[346] These storms result from variations in the solar wind that produces major changes in the currents, plasmas, and fields in Earth's magnetosphere.[347] The largest storms that result from these conditions are associated with solar coronal mass ejections (CMEs) where a billion tons or so of plasma from the sun, with its embedded magnetic field, arrives at Earth.[348] CMEs typically take several days to arrive at Earth, but have been observed, for some of the most intense storms, to arrive in as short as 18 hours.[349]

Risk Profile

[346] Dahl, Shawn, NOAA, Space Weather Forecaster (2019).
[347] Space Weather Prediction Center, National Oceanic and Atmospheric Administration, Geomagnetic Storms, (NOAA), www.swpc.noaa.gov/phenomena/geomagneticv-storms (last accessed March 17, 2016)
[348] Dahl, Shawn, NOAA, Space Weather Forecaster (2019).
[349] Space Weather Prediction Center, National Oceanic and Atmospheric Administration, Geomagnetic Storms, (NOAA), www.swpc.noaa.gov/phenomena/geomagneticv-storms (last accessed March 17, 2016)

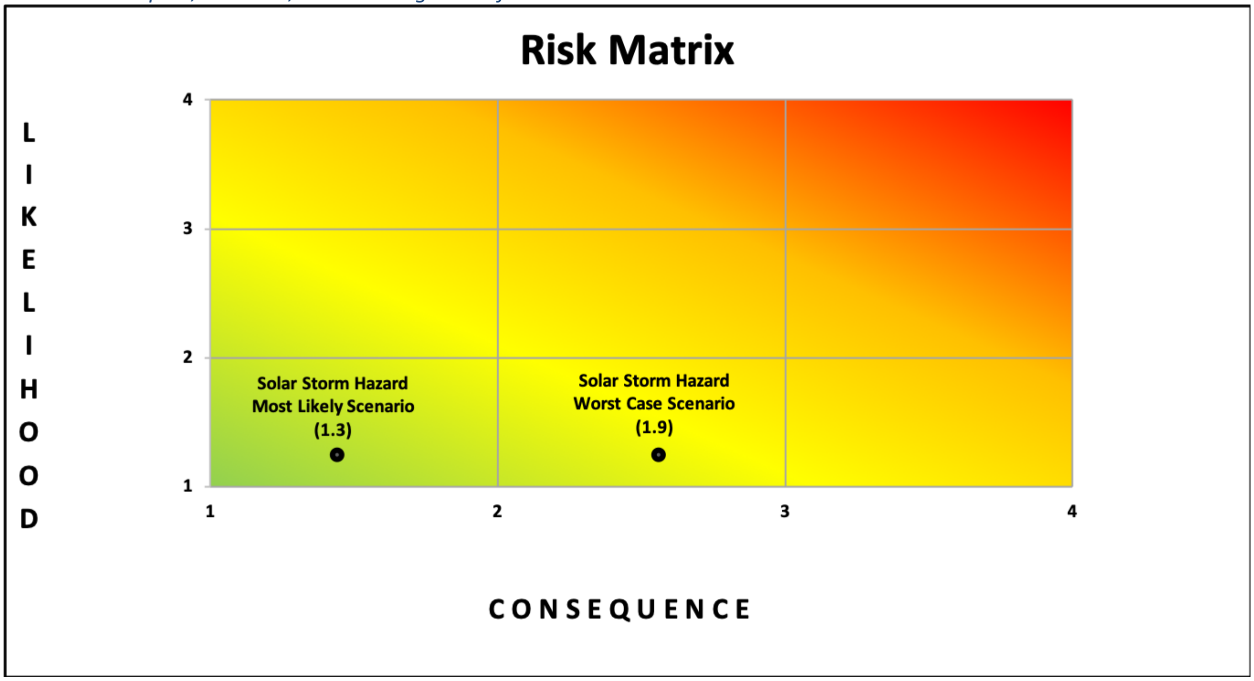
The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

Solar Storm Risk Profile					
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	1.25 Unlikely- Infrequent		50%
CONSEQUENCE	**Impact**	1.3 Limited-Significant	2.7 Significant-Critical	40%
	Warning Time	1 Very Long	1 Very Long	5%
	Duration	3 Long	3 Long	5%
TOTAL RISK SCORE		**1.3**	**1.9**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

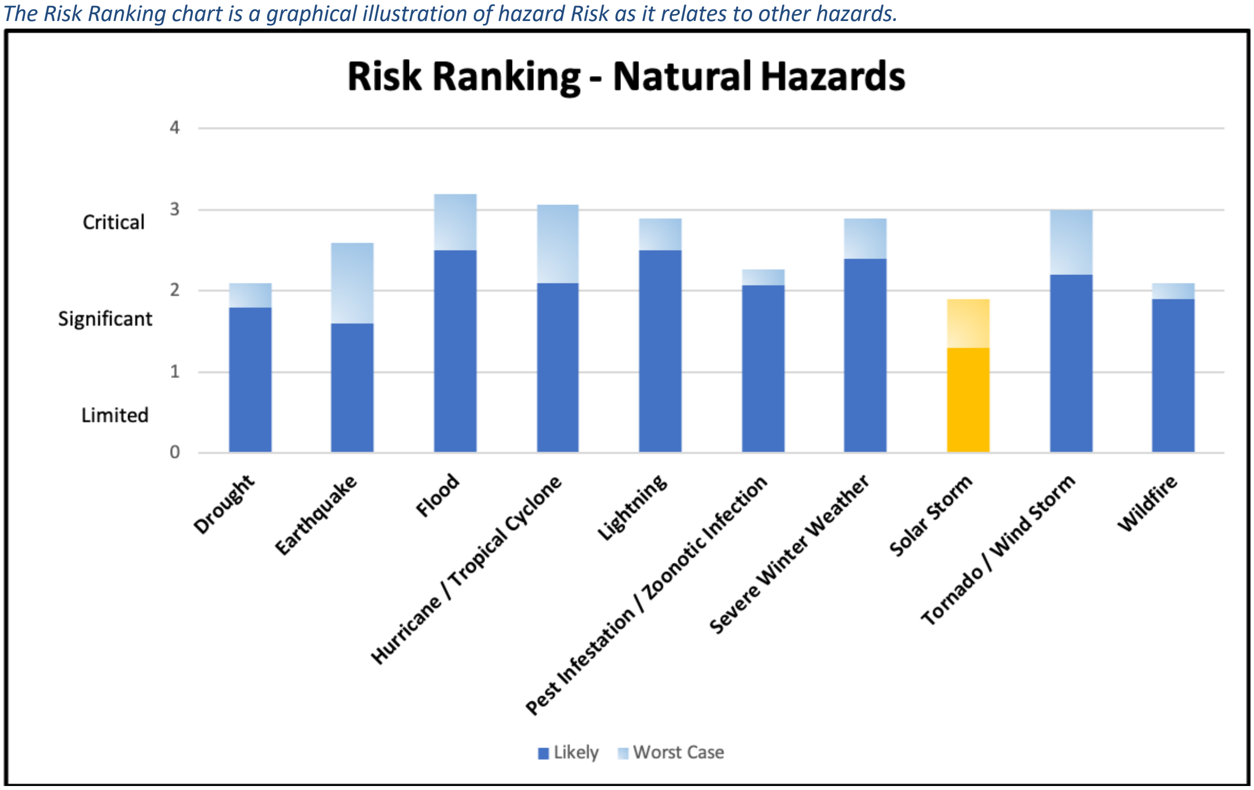
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Solar Storms are a type of Space Weather. Space weather "is generally divided into four components: solar flares, coronal mass ejections (CMEs), high speed solar wind, and solar energetic particles."[350] The type of space weather that is most relevant to Howard County is the threat of Geomagnetic Storms which fall under coronal mass ejections.[351] A geomagnetic storm is "a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding Earth."[352] These storms result from variations in the solar wind that produces major changes in the currents, plasmas, and fields in Earth's magnetosphere.[353] The largest storms that result from these conditions are associated with solar CMEs where a billion tons or so of plasma from the sun, with its embedded magnetic field, arrives at Earth.[354] CMEs typically take several days to arrive at Earth, but have been observed, for some of the most intense storms, to arrive in as short as 18 hours.[355] These storms could cause disturbances in the electric power grid, which could negatively impact homes and businesses in Howard County.

In a severe or extreme geomagnetic storm, electric power grid systems could suffer from widespread voltage control problems and possible transformer damage. In a worst-case scenario, such storms could result in complete power grid collapse or blackouts. When magnetic fields move about in the vicinity of a conductor, such as a wire, an electric current is induced into the conductor. This happens on a grand scale during geomagnetic storms. By receiving geomagnetic storm alerts and warnings, power companies can minimize damage and power outages.[356]

Besides the risk to the electric power grid, space weather could have other potential impacts on the ability to conduct timely and uninterrupted emergency response related communication for or among the people of Howard County. Examples include: solar radiation storms that could cause disruption of satellite communication which could disrupt a wide variety of communication methods or Global Navigation Satellite System (GNSS) (i.e. Global Positioning System (GPS)) location precision; or Radio Blackouts of high-frequency (HF) communication due to an energetic solar flare during the daylight hours could result

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[350] Dahl, Shawn, NOAA, Space Weather Forecaster (2019).
[351] Garner, R. (2015, March 19). Solar Storm and Space Weather - Frequently Asked Questions. Retrieved from https://www.nasa.gov/mission_pages/sunearth/spaceweather/index.html#q7.
[352] Dahl, Shawn, NOAA, Space Weather Forecaster (2019).
[353] Space Weather Prediction Center, National Oceanic and Atmospheric Administration, Geomagnetic Storms, (NOAA), www.swpc.noaa.gov/phenomena/geomagneticv-storms (last accessed March 17, 2016)
[354] Dahl, Shawn, NOAA, Space Weather Forecaster (2019).
[355] Space Weather Prediction Center, National Oceanic and Atmospheric Administration, Geomagnetic Storms, (NOAA), www.swpc.noaa.gov/phenomena/geomagneticv-storms (last accessed March 17, 2016)
[356] Space Weather Prediction Center, National Oceanic and Atmospheric Administration, A Profile of Space Weather, http://www.swpc.noaa.gov/sites/default/files/images/u33/primer_2010_new.pdf, (last accessed March 17, 2016)

in inability to communicate via HF radio emergency bands, commercial terrestrial radio, or Amateur Radio networks aiding in emergency response.[357]

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

Solar storms are a part of space weather and occur when energy blasts off from the sun interacts with the Earth's atmosphere and geomagnetic field.[358] The best-known example of a space weather's affect is the collapse of the Hydro- Quebec power network that caused a transformer failure and led to a blackout that lasted nine hours and affected six million people.[359] Additionally, in October 2003, a geomagnetic storm caused power grid disturbances and fluctuations in North America. The impact of the geomagnetic storm tripped a capacitor in the northwest and heated a transformer in the northeast.

Shawn Dahl, NOAA Space Weather Forecaster, further explains that,

> "during solar storms, also known as geomagnetic storms, the sky is filled with bright auroras in several northern U.S. states including Minnesota, Wisconsin, Montana, the Dakotas, and Washington. Although the sky is beautifully lit up, solar storms can cause a disruption to our daily lives. The electric grid, power to homes and business can be affected, and people who use GPS navigation will also be interrupted. Although the solar storms can last from a few minutes to several hours, the affects linger in the Earth's atmosphere for days and maybe even weeks.
>
> Solar storms are monitored and observed by scientists utilizing a variety of ground- and space-based sensors and imaging systems to view activity at various depths in the atmosphere. Telescopes are used to detect visible light, ultraviolet light, gamma rays, and X rays. Receivers and transmitters are used to detect a radio shock wave that is created when a CME crashes into the solar wind and produces a shock wave. Particle detectors are used to count ions and electrons, magnetometers record changes in magnetic fields, and ultraviolet while visible cameras observe auroral patterns above the Earth."[360]

Geomagnetic storms are the highest space weather concern for Howard County. These storms are categorized by the NOAA Space Weather Scales rating from G-1 (minor) to G-5 (extreme).[361] The risk of hazard intensifies when coupled with extreme weather that has already stressed the power grid, inclining heat waves, blizzards, winter storms, tropical systems, and tornadoes.

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[357] All the data from this section of the HIRA was provided by the NOAA.
[358] Rice, D. (2015, March 18). Severe solar storm hitting Earth. Retrieved from http://www.usatoday.com/story/weather/2015/03/17/solar-geomagnetic-storm/24901903/ (last accessed October 10, 2019).
[359] Garner, R. (2015, March 19). Solar Storm and Space Weather - Frequently Asked Questions. Retrieved from https://www.nasa.gov/mission_pages/sunearth/spaceweather/index.html#q11 (last accessed October 8, 2019).
[360] Dahl, Shawn, NOAA, Space Weather Forecaster (2019).
[361] NOAA Space Weather Scales, NOAA Space Weather Scales | NOAA / NWS Space Weather Prediction Center, https://www.swpc.noaa.gov/noaa-scales-explanation (last accessed Jun 27, 2019).

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

Notable Incidents within Howard County

There have been no notable occurrences of Space Weather having an impact in Howard County within the reviewed time period.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

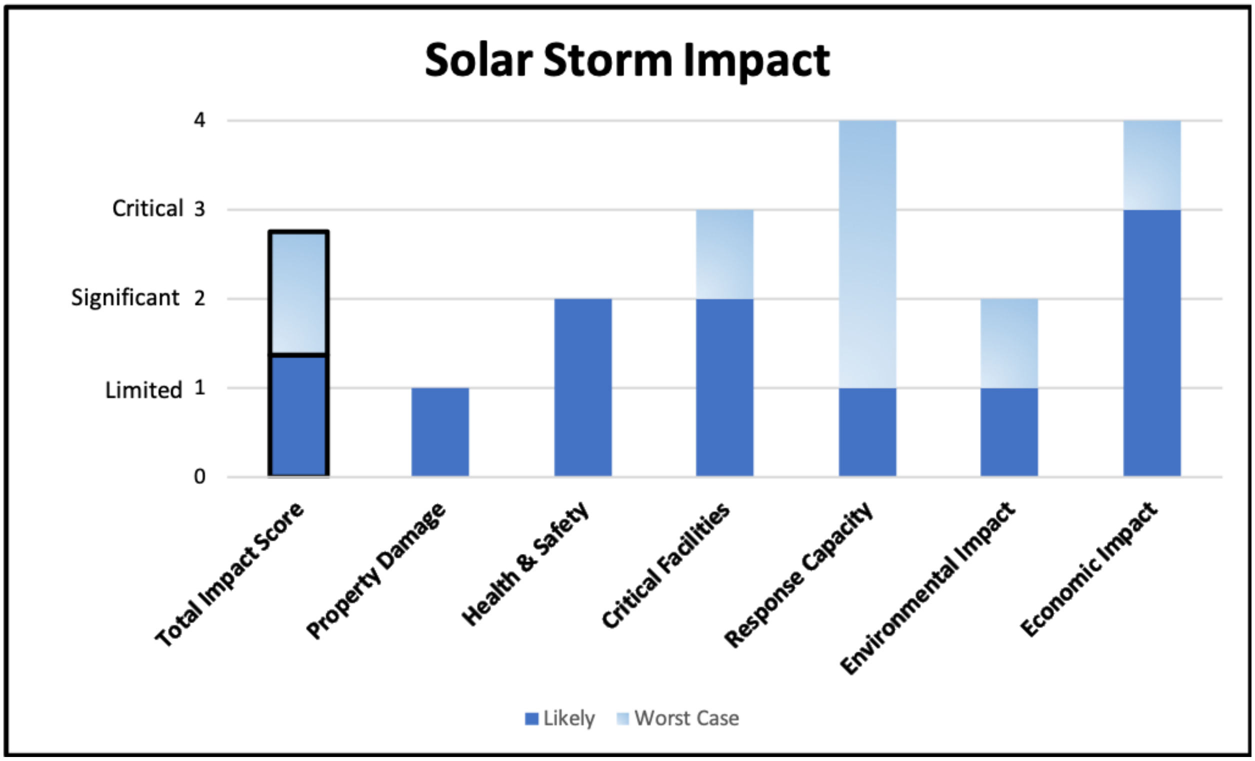
Future Likelihood of Solar Storms in Howard County	
Historical Average (time period)	No notable occurrences
Historical Annual Probability	0% chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	0-10% chance of annual occurrence
Future Likelihood Score[73]	1.25 (Unlikely- Infrequent)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: The future annual probability of the hazard occurring is 0-10% chance of annual occurrence, or, one event every 10-100 years. A space weather hazard has occurred historically, specifically, geomagnetic storms have caused power grid blackouts in the past. This coupled with population density and the high use of electronics within the County may impact the future likelihood of the hazard occurring.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Solar Storm Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Very Long.* There would be several days warning time for a potential heat wave followed by a three day warning time for Geomagnetic Storm Watch for G1, G2, and G3 or higher levels of activity.	*Very Long.* There would be several days warning time for a potential heat wave followed by a three day warning time for Geomagnetic Storm Watch for G1, G2, and G3 or higher levels of activity.
DURATION	*Long.* Five days.	*Long.* The geomagnetic storm contribution would likely be random, last for a few hours to much of a day; but likely in short bursts of escalated activity (several hours to half a day) during one to five days of this level of geomagnetic storm threat during a devastating three week long period of a heat wave.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Solar Storm Consequence Analysis Likely		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ Critical and non-critical infrastructure will be damaged. ▪ Possibility of critical and high voltage switch gear being destroyed, and back-up generators may be worn out. ▪ Possible issues to communication and potential concerns with traffic signals are expected.
HEALTH AND SAFETY	*Significant*	▪ Unknown deaths are expected. Lightning and electrocution are the most common causes of death. Complications due to extreme heat are the most common causes of death. Citizens requiring power use for life sustaining interventions would be impacted. For those individuals, underlying medical conditions are the most common causes of death. ▪ Unknown injuries likely.
CRITICAL FACILITIES	*Significant*	▪ *Utilities* – minor disruption due to brownouts. ▪ *Information/Communication* – minor disruption due to brownouts. ▪ *Transportation* – minor disruption due to brownouts.
RESPONSE CAPACITY	*Limited*	▪ *Police* – Local resources adequate. Low impact to response capability or continuity of operations. May cause law enforcement to use radio, computer communication for a limited period of time. Land lines will be required for communication. ▪ *Fire and Rescue* – Local resources adequate. Limited impact to response capability. Communication issues will be the most impacted. ▪ *Health* – Mutual aid needed. Administrative duties will be on hold until communication can be restored. Clinical Services can continue to provide services and maintain mutual charts of their patients. ▪ *Public Works* – Local resources adequate. Any responses that have potential failure nodes due to electronic communications are impacted.
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal impact on air, water, and land is expected. ▪ Limited environmental impact is expected.
ECONOMIC IMPACT	*Critical*	▪ Business disruption, closure and extended period of electrical, and telecommunications and IT infrastructure damage assessment and repair in economic consequences. ▪ Critical economic impact.
TOTAL IMPACT[362]	***Limited-Significant***	▪ **Total Impact Score: 1.375 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[362] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

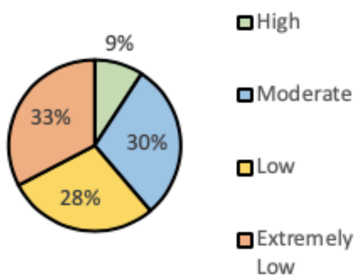
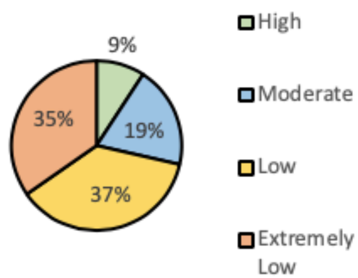
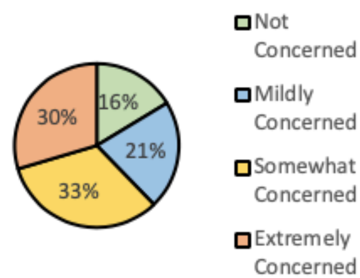
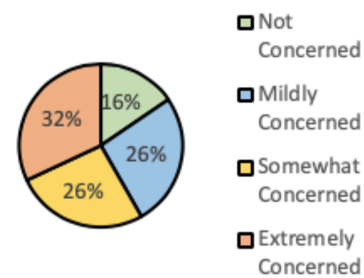
Solar Storm Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ Less than 5% of critical and non-critical infrastructures will be damaged. ▪ Some traffic signals may be out of service especially along state roadways.
HEALTH AND SAFETY	*Significant*	▪ Unknown deaths are expected. Lightning and electrocution are the most common causes of death. Complications due to extreme heat are the most common causes of death. Citizens requiring power use for life sustaining interventions would be impacted. For those individuals, underlying medical conditions are the most common causes of death. ▪ Unknown injuries likely.
CRITICAL FACILITIES	*Critical*	▪ *Utilities* – Three weeks+ of critical facilities will be shut down. Some buildings may need to be shut down for extended periods of time. ▪ *Information/Communications* – Outages up to a week or may take longer. ▪ *Transportation* – Nearly all critical facilities will be out of service. No fuel, no food in stores, and no clean water are also expected due to facilities being out of service.
RESPONSE CAPACITY	*Catastrophic*	▪ *Police* – Moderate need for state or federal assistance. Sheriff's Office may be needed to support operations. Moderate impact to response capability or continuity of operations. May cause law enforcement to use radio, computer communication for a limited period of time. Land lines will be required for communication. Emergency response methods that utilize HF radio for search and rescue or emergency communication, or response agencies that rely upon precision navigation are impacted. ▪ *Fire and Rescue* – Significant and long-lasting need for state and federal assistance. Significant COOP issues and access for functional needs communities. Emergency response methods that utilize HF radio for search and rescue or emergency communication, or response agencies that rely upon precision navigation are impacted. ▪ *Public Works* – Significant and long-lasting need for state or federal assistance.
ENVIRONMENTAL IMPACT	*Significant*	▪ Minimal direct impact on air, water, and land resources, but loss of power and distribution of communications can cause air, water, and land pollution if it disrupts facilities such as pipelines carrying hazardous materials, industrial manufacturing plants, or sewage treatment plants. Limited-Significant environmental impact is expected.
ECONOMIC IMPACT	*Catastrophic*	▪ Loss of electrical, communication, transportation management, and security bring life to a standstill in economic consequences.
TOTAL IMPACT[363]	***Significant-Critical***	▪ **Total Impact Score: 2.75 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[363] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes public perceptions of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Solar Storm Hazard Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
			
Average: 2.15 Low - Moderate	*Average: 2.03 Low - Moderate*	*Average: 2.76 Mildly Concerned - Somewhat Concerned*	*Average: 2.74 Mildly Concerned - Somewhat Concerned*

Tornado/Wind Storm Hazard

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

The following hazard discusses Wind Storms and Tornadoes. Wind Storms are discussed in two separate categories: thunderstorm winds, and high wind events. These events will be discussed separately within this section. A tornado is "a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud."[364] Tornadoes are related to larger vortex formations, and therefore often form in convective cells such as thunderstorms or in the right forward quadrant of a hurricane, far from the hurricane eye.

The Enhanced Fujita (EF)scale is used to assign tornado ratings. The EF scale "incorporates 28 damage indicators (DIs) such as building type, structures, and trees. For each damage indicator, there are 8 degrees of damage (DOD) ranging from the beginning of visible damage to complete destruction of the damage indicator. […] For example, with the EF Scale, an EF3 tornado will have estimated wind speeds between 136 and 165 mph (218 and 266 kph)."[365]

EF Scale[366]

FUJITA SCALE			DERIVED EF SCALE		**OPERATIONAL EF SCALE**	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	**EF Number**	**3 Second Gust (mph)**
0	40-72	45-78	0	65-85	**0**	**65-85**
1	73-112	79-117	1	86-109	**1**	**86-110**
2	113-157	118-161	2	110-137	**2**	**111-135**
3	158-207	162-209	3	138-167	**3**	**136-165**
4	208-260	210-261	4	168-199	**4**	**166-200**
5	261-318	262-317	5	200-234	**5**	**Over 200**

[364] *Glossary of Meteorology*, American Meteorological Society (2000), available at http://www.spc.noaa.gov/faq/tornado/ (last accessed October 1, 2019).
[365] US Department of Commerce, & Noaa. (2018, August 14). Enhanced Fujita Scale. Retrieved from https://www.weather.gov/tae/ef_scale.
[366] Citation: Enhanced F Scale for Tornado Damage. Retrieved from https://www.spc.noaa.gov/faq/tornado/ef-scale.html (last accessed October 1, 2019).

Damaging winds are often called "straight-line" winds to differentiate the damage they cause from tornado damage. Strong thunderstorm winds can come from a number of different processes. Most thunderstorm winds that cause damage at the ground are a result of outflow generated by a thunderstorm downdraft. Damaging winds are classified as those exceeding 50-60 mph.

Damage from severe thunderstorm winds account for half of all severe reports in the lower 48 states and is more common than damage from tornadoes.[367] Wind speeds can reach up to 100 mph and can produce a damage path extending for hundreds of miles.[368]

Risk Profile

The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

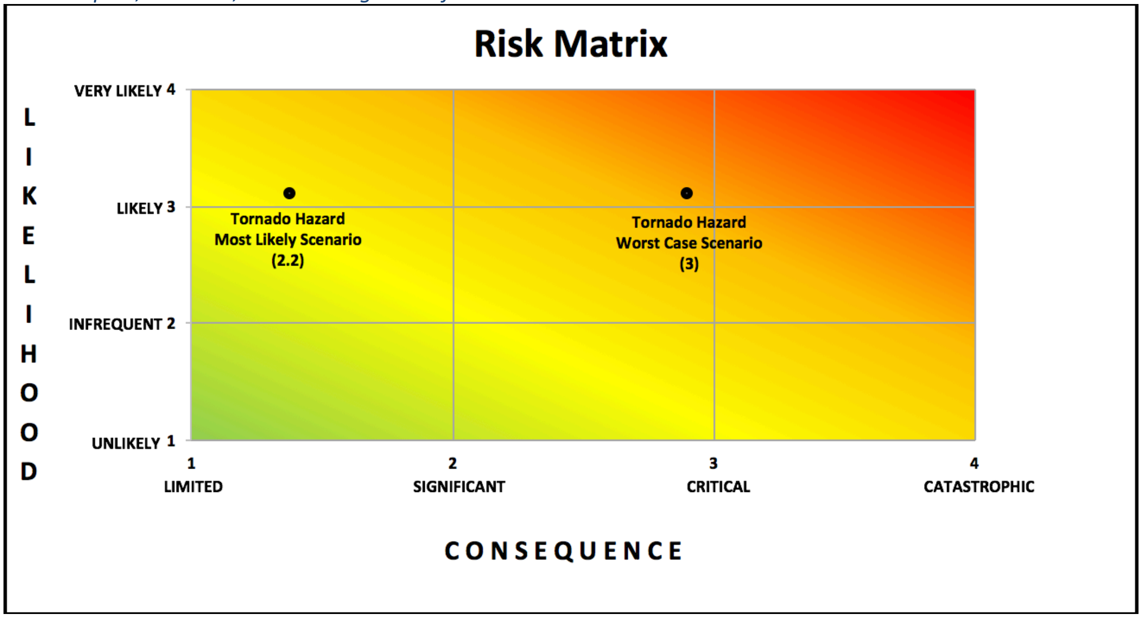
Tornado/Wind Storm Risk Profile				
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	3.1 Likely		50%
CONSEQUENCE	**Impact**	1.1 Limited	3 Critical	40%
	Warning Time	4 Short	4 Short	5%
	Duration	1 Short	1 Short	5%
TOTAL RISK SCORE		**2.2**	**3**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

[367] NOAA. Damaging Winds Basics. Retrieved from https://www.nssl.noaa.gov/education/svrwx101/wind/ (last accessed October 1, 2019).
[368] NOAA. Damaging Winds Basics. Retrieved from https://www.nssl.noaa.gov/education/svrwx101/wind/ (last accessed October 1, 2019).

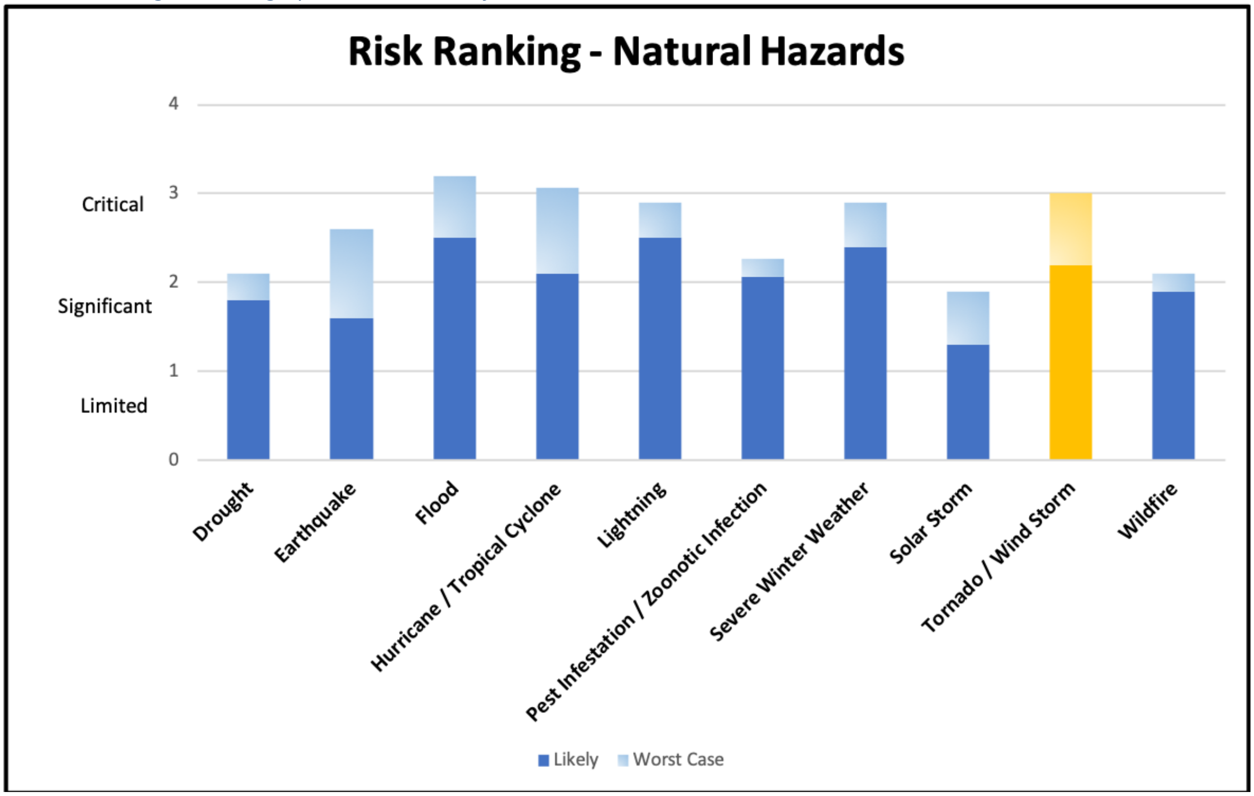
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

A tornado is "a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud."[369] Most of the time, vortices remain suspended in the atmosphere. When the lower tip of a vortex touches the earth, the tornado forms and often becomes a force of destruction.[370] Tornadoes are related to larger vortex formations, and therefore often form in convective cells such as thunderstorms or in the right forward quadrant of a hurricane, far from the hurricane eye. The most destructive tornadoes are formed in the most powerful thunderstorms, known as supercells, which have a well-defined radar circulation called a mesocyclone.[371] Tornadoes can form at any time, with the Nation's season of greatest activity running from March to August. The peak of tornado activity usually occurs in April, May, and June in the United States. The *2008 State of Maryland Hazard Mitigation Plan*, states that July is the peak month for tornado activity in Maryland.[372] Tornadoes can occur at any time of the day, although they are more likely to occur between 4 p.m. and 9 p.m.[373] This is because "by this time the sun has heated the ground and the atmosphere enough to produce thunderstorms."[374]

Wind Storms are categorized in the NCDC database as thunderstorm winds and high wind events. Within these Wind Storm Events are two basic types of winds that may affect Howard County: Mesoscale and Microscale winds. Either type of Wind Storm Events may result in property damage and loss of life. Mesoscale winds are high winds that are long-lasting and occur over a large area. They are typically associated with a cold frontal passage or a nor'easter. Microscale winds last a short time period and are confided to a small area. Microscale winds are commonly associated with thunderstorms. When a thunderstorm produces winds over 50 kts (roughly 58 mph), that thunderstorm is considered severe.

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[369] *Glossary of Meteorology*, American Meteorological Society (2000), available at http://www.spc.noaa.gov/faq/tornado/ (last accessed October 1, 2019).
[370] Other definitions stress the destructive nature of tornadoes. For example, the Red Cross describes a tornado as a "violently rotating column of air extending from the base of a thunderstorm down to the ground." *Tornado Safety Checklist*, https://www.redcross.org/content/dam/redcross/atg/PDF_s/Preparedness___Disaster_Recovery/Disaster_Preparedness/Tornado/Tornado.pdf (last accessed October 1, 2019).
[371] For additional information about tornadoes, see *NOAA's Severe Weather*, https://www.spc.noaa.gov/ (last accessed October 1, 2019).
[372] See also, US Department of Commerce, and Noaa. (2013, August 3). Months of Peak Tornado Occurrence. Retrieved from https://www.weather.gov/cae/tornadobymonth.html (last accessed October 1, 2019).
[373] NOAA. Tornado Basics. Retrieved from https://www.nssl.noaa.gov/education/svrwx101/tornadoes/ (last accessed October 1, 2019).
[374] Staff, N. G. (2019, August 28). Tornadoes, explained. Retrieved from https://www.nationalgeographic.com/environment/natural-disasters/tornadoes/.

A downburst is "the general term used to broadly describe macro and microbursts."[375] Downbursts result from a sudden descent of cold air hitting the ground and spreading outward, thus creating a high wind event. A downburst can have devastating effects. According to NOAA, there are two types of downbursts, a microburst and a macroburst. A microburst is a small downburst that brings damaging winds up to 168 mph, over an area of two and a half miles, and lasts five to fifteen minutes. A macroburst is a large downburst that causes tornado-like damage, where winds can reach 134 mph, over an area of two and a half miles, and lasts five to thirty minutes.[376]

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

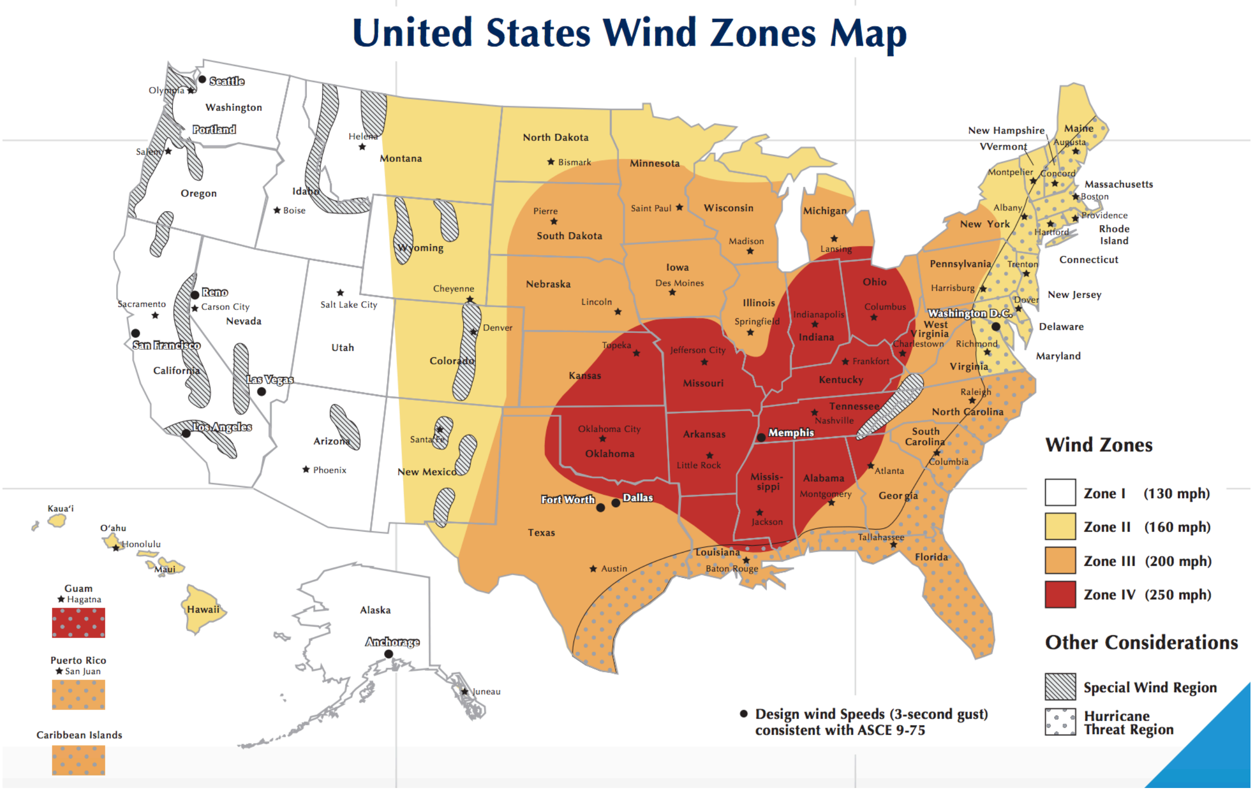
Compared to the central United States, the risk of a tornado occurring in Howard County is present but relatively low. From 1950 to 2019, the NCDC database indicates that Maryland has experienced 373 tornadoes, an average of less than six per year.[377] Tornadoes can occur at any time, with the greatest frequency during the late spring and early summer months, and during late afternoon and early evening hours. Within Howard County, the risk to people and property from tornadoes cannot be distinguished by area; the hazard has a uniform probability of occurrence across the County. Although the impact of a tornado event will be different in different parts of the County, all people and assets are considered to have the same degree of exposure. This is the same for mesoscale and microscale wind events.

The figures below show how the frequency and strength of extreme windstorms that vary across the United States.

375 Damaging Winds Types. Retrieved from https://www.nssl.noaa.gov/education/svrwx101/wind/types/ (last accessed October 1, 2019).
376 For additional information about severe thunderstorms and high winds, see Downburst Wind Awareness, https://www.weather.gov/cae/downburst.html (last accessed October 1, 2019).
377 Damaging Winds Types. Retrieved from https://www.nssl.noaa.gov/education/svrwx101/wind/types/ (last accessed October 1, 2019).

Wind Zones in the United States

(Source: Ontario County, NY. Chapter-5-Risk-Assessment-Maps)



Wind Zones in the United States Zoomed-in Image of Maryland

(Source: Ontario County, NY. Chapter-5-Risk-Assessment-Maps)

[378]

378 Ontario County, NY. Chapter-5---Risk-Assessment-Maps---United-States---Seismic-and-Wind-Zones. Retrieved from https://www.co.ontario.ny.us/DocumentCenter/View/3445/Chapter-5---Risk-Assessment-Maps---United-States---Seismic-and-Wind-Zones.

III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

The NCDC database reports that 17 tornadoes have occurred in Howard County between 1975 and 2019.[379] The database indicates there were eight EF0, seven EF1, and two EF2 tornadoes. The table below summarizes the 17 tornadoes that have occurred within Howard County. With a total of 17 tornado events between 1975 and 2019 Howard County experiences, on average, 1.5 tornadoes every four years. Based on this information, it is possible to infer an approximate 38% annual probability of occurrence countywide. Depending on atmospheric conditions, it is possible for any number of tornadoes to occur in any given year. Based on the history of tornadoes in Howard County, there is a high probability of future tornadoes occurring in the Howard County.

Howard County: Tornado Events 1975 – October 2019

(Source: NOAA/NCDC)

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	3	3.998M	0.00K
HOWARD CO.	HOWARD CO.	MD	07/03/1975	15:35	CST	Tornado	F0	0	0	0.00K	0.00K
HOWARD CO.	HOWARD CO.	MD	07/31/1978	19:15	CST	Tornado	F2	0	0	250.00K	0.00K
HOWARD CO.	HOWARD CO.	MD	08/28/1992	15:00	CST	Tornado	F1	0	2	2.500M	0.00K
HOWARD CO.	HOWARD CO.	MD	08/28/1992	15:20	CST	Tornado	F0	0	0	2.50K	0.00K
West Friendship	HOWARD CO.	MD	07/06/1995	16:07	EST	Tornado	F0	0	0	75.00K	0.00K
COLUMBIA	HOWARD CO.	MD	08/27/1996	13:50	EST	Tornado	F0	0	0	15.00K	0.00K
SAVAGE	HOWARD CO.	MD	07/10/2000	16:30	EST	Tornado	F1	0	0	50.00K	0.00K
NORTH LAUREL	HOWARD CO.	MD	09/24/2001	16:41	EST	Tornado	F2	0	0	1.000M	0.00K
ALPHA	HOWARD CO.	MD	07/31/2009	13:42	EST-5	Tornado	EF1	0	0	0.00K	0.00K
WATERSVILLE JCT	HOWARD CO.	MD	06/01/2012	13:52	EST-5	Tornado	EF1	0	0	5.00K	0.00K
SCAGGSVILLE	HOWARD CO.	MD	06/01/2012	15:29	EST-5	Tornado	EF0	0	0	100.00K	0.00K
SAVAGE	HOWARD CO.	MD	10/15/2014	12:13	EST-5	Tornado	EF0	0	0	0.00K	0.00K
SAVAGE	HOWARD CO.	MD	09/29/2015	21:05	EST-5	Tornado	EF0	0	0	0.00K	0.00K
FLORENCE	HOWARD CO.	MD	06/21/2016	12:29	EST-5	Tornado	EF0	0	0	0.00K	0.00K
LONG CORNER	HOWARD CO.	MD	11/02/2018	19:19	EST-5	Tornado	EF1	0	0	0.00K	0.00K
HIGHLAND	HOWARD CO.	MD	05/23/2019	14:27	EST-5	Tornado	EF1	0	1	0.00K	0.00K
KNOLLWOOD	HOWARD CO.	MD	05/30/2019	14:20	EST-5	Tornado	EF1	0	0	0.00K	0.00K
Totals:								0	3	3.998M	0.00K

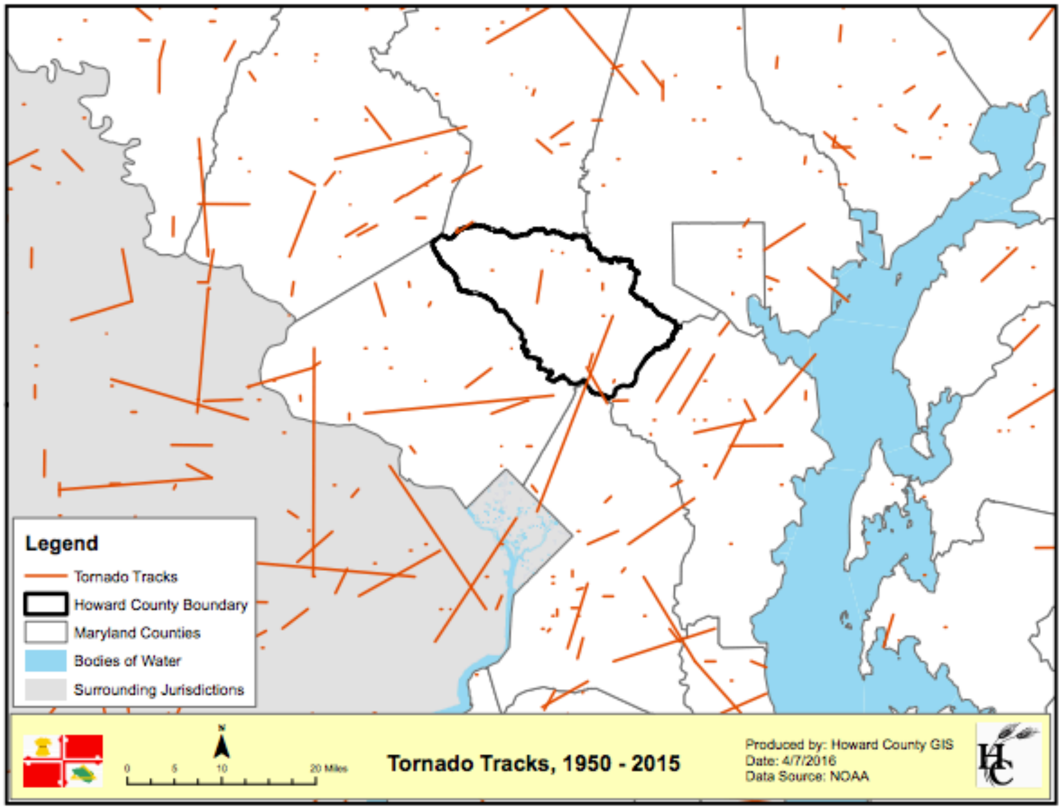
380

[379] NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(C)+TornadoandbeginDate_mm=01andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=01andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 1, 2019).

[380] Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(C)+TornadoandbeginDate_mm=01andbeginDate_dd=01andbeginDate_yyyy=1975andendDate_mm=10andendDate_dd=01andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 1, 2019).

The figure below identifies the tornado tracks for Howard County and the surrounding area between 1950 and 2015.[381]

Tornado Tracks for Howard County and Surrounding Area, 1950- 2015
(Source: NOAA, Howard County GIS)



[382]

Notable Tornado Incidents in Howard County

July 31st, 1978 (EF2) - The tornado was estimated to be 40 yards wide and travelled for a length of $^{8}/_{10}$ mile, causing $971,846[383] in damage.

July 6th, 1996 (EF0) - A small tornado briefly touched down in a wooded area, just south of Interstate 70 near the Marriottsville Road Exit. The tornado was only 20 yards wide and traveled $^{1}/_{10}$ mile. One house between Marriottsville and Ellicott City was heavily damaged by a falling tree. In total, an estimated $168,585[384] in property damage occurred.

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381 This data does not contain Howard County's most recent tornadoes, including tornadoes that occurred after 2015.
382 NOAA, Howard County GIS. Tornado Tracks, 1950 - 2015. (2016, April 7). Retrieved from https://data.howardcountymd.gov/MapGallery/Bucket/144_HowardCountyTornadoTracks.pdf (last accessed October 1, 2019).
383 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $826,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
384 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 1996 was $103,100. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

August 27th, 1996 (EF0) - A small tornado caused damage to several subdivisions along Frederick Road north of Columbia. A total of four trees were knocked down, including two trees that were blown into a home on Pine Bluffs Drive. The NCDC database estimates that there was $33,684[385] in property damages.

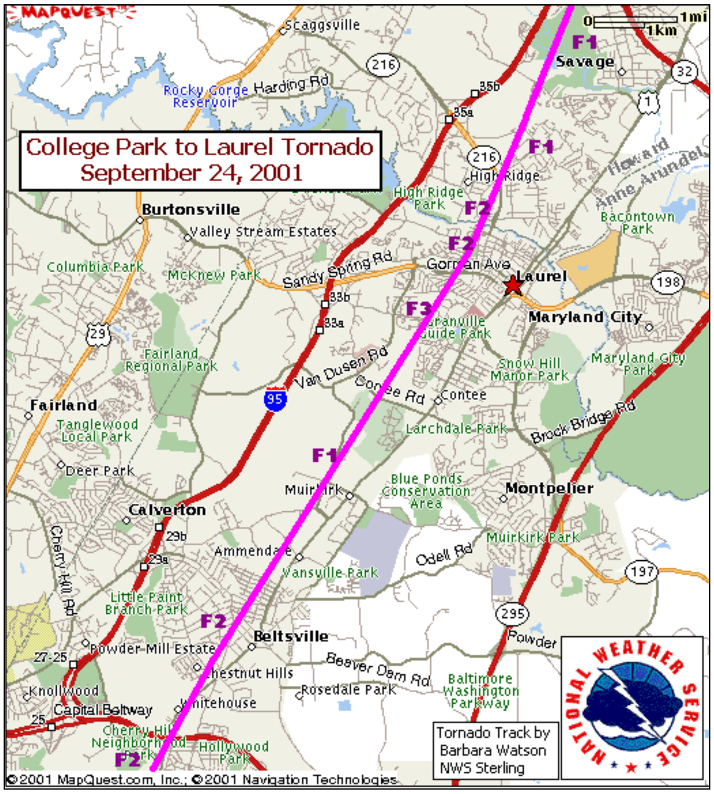
July 10th, 2000 (EF1) - The tornado touched down three miles southeast of Savage. It brought down several trees and power lines. It also blew over two trailers and three semi-tractor trailers. In Howard County, the tornado was 100 yards wide and traveled $^{6}/_{10}$ mile before moving into Anne Arundel County. The tornado resulted in $93,266[386] in property damage.

September 24th, 2001 (EF2-EF3) - The tornado originated in Prince George's County as an EF3 and travelled north-northeast from Hyattsville, through College Park, and into Laurel. Along its destructive path, the tornado killed two and injured 55. Just before the tornado crossed into Howard County, it weakened from an EF3 to an EF2 tornado. In Howard County, the tornado caused severe damage to several townhomes in Settler's Landing, a subdivision in North Laurel. As the tornado continued northward, it slowly dissipated and ended one mile east-southeast of Columbia. The tornado traveled a total distance of six miles in Howard County and had a width of 100 yards. Along its destructive path, the tornado uprooted trees, blew off rooftops, and blew out car windows. Many homes were deemed unsafe for a period of time, and one was severely damaged. Property damage in Howard County was estimated at $145.1 million. [387] The figure below shows the College Park tornado track as it moved northeast from Beltsville to Laurel.

[385] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 1996 was $20,600. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[386] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2000 was $62,600. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[387] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $123.4 million. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

September 24th, 2001 Tornado Track – College Park to Laurel

(Source: National Weather Service – Baltimore/Washington Office, September 24th, 2001 Tornadoes)



June 1st, 2012 (EF1) - The tornado traveled 2.07 miles in Watersville Junction. Property damage totaled to $5,587[388] according to the NCDC/NOAA database. 30-40 large hardwood trees were uprooted or snapped.

June 1st, 2012 (EF0) - The tornado traveled 1.58 miles in Scaggsville. It brought down several trees, caused roof damage to several homes, and a Day Care Center's chimney blew over. The property damage totaled to $111,744[389] according to the NCDC/NOAA database.

June 30th, 2016 (EF0) - The tornado traveled nearly 13 miles through Western Howard County. There were no injuries or deaths associated, hundreds of trees were knocked down and several homes had serious damage from falling debris. The path of debris was over 500 yards wide at some points.

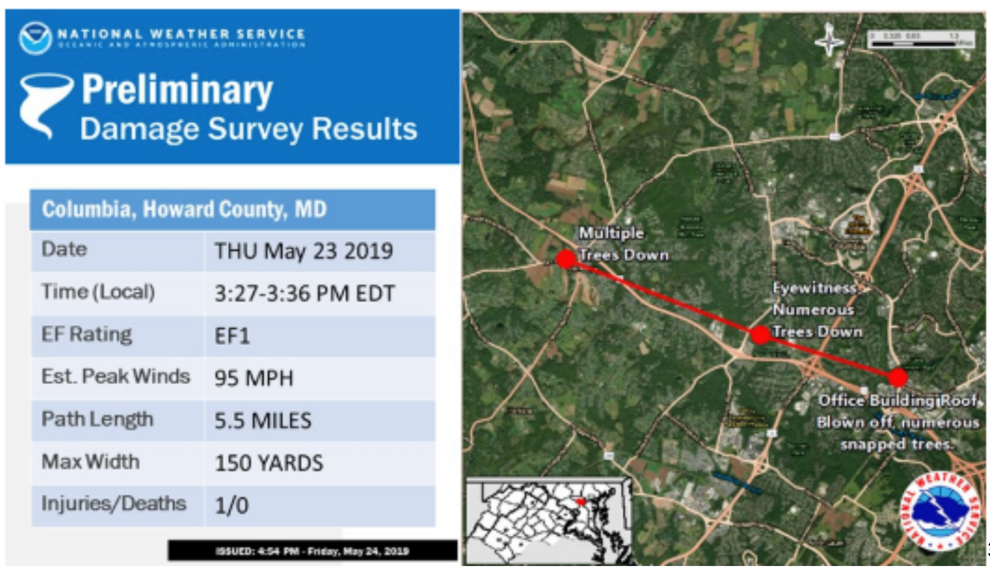
[388] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2012 was $5,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

[389] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2012 was $100,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

November 2nd, 2018 (EF1) - The tornado traveled 0.59 miles through Long Corner. There were no deaths or injuries reported, however, several wooden power poles were snapped along Penn Shop Road according to the NCDC/NOAA database.

May 23rd, 2019 (EF1) - The tornado traveled 5.53 miles through Highland, near Clarksville. There was one injury reported and no deaths according to the NCDC/NOAA database. Several trees were uprooted or snapped, one falling onto the roof of a house. Additionally, an office building lost part of its roof.

May 30th, 2019 (EF1) - The tornado traveled 4.49 miles through Knollwood. There were no deaths or injuries reported according to the NCDC/NOAA database. The tornado ripped sections of roofing desk off of homes, ripped off barn roofing, uprooted trees, and downed powerlines. Additionally, the tornado damaged the Howard County Highway Maintenance Facility. "At the facility, the tornado ripped off its tin roofing, damaged some roof framing, tore a large section of fabric from a salt dome, destroyed garage bay doors, [and] damaged fencing."[390]



391

Wind Storm Events

The HIRA discusses Wind Storm events in addition to Tornadoes. Wind Storms are broken down into two categories, Thunderstorm Winds and High Wind events based on how data is recorded in the NCDC. The NCDC database reports that 232 Thunderstorm and High Wind Events have occurred in Howard County between 1969 and September of 2019.[392] Of the 232 events, 37 included winds of 60 kts (69 mph) or

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[390] NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=826673 (last accessed October 1, 2019).

[391] US Department of Commerce, & Noaa. (2019, May 24). EF-1 Tornado Confirmed in Howard County, MD on May 23rd. Retrieved from https://www.weather.gov/lwx/ef1howardcounty.

[392] Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(C)+Thunderstorm+WindandbeginDate_mm=01andbeginD

greater.[393] The database indicates that there were eight thunderstorm wind events that caused at least $50,000 damages since 1950.[394] On May 15th, 1994, a thunderstorm, with winds exceeding 50 kts, damaged several homes and knocked down numerous trees in the central and eastern portions of the County. The total impact was estimated to be $85,301[395] in property damages. On May 13th, 2002, a 75 mph downburst occurred within a 10 square block area Northwest of Ellicott City. Numerous trees were brought down and the downburst caused widespread power outages. Two homes were heavily damaged by downed trees. The estimated total property damage for the downburst was $212,488.[396] With a total of 232 Thunderstorm/High Wind events between 1969 and 2019, Howard County experiences on average 4.6 Thunderstorm/High Wind events per year. With 4.6 storms per year, there is a 100% annual probability of a thunderstorm wind event occurring in Howard County. Based on the history of past Thunderstorm/High Wind events, there is a high probability of these events occurring in Howard County in the future. Although the probability is high, the impact on life and property in the County will probably be minimal as compared to other hazards. The table below summarizes the 10 Thunderstorm/High Wind Events in Howard County with greater than 60 kt winds since 2015.

Howard County: Thunderstorm Wind Events Over 60 Knots, Excluding Tornado Winds, 2015 – September, 2019

(Source: NOAA/NCDC)

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	0	3.00K	0.00K
EAST LIOAK	HOWARD CO.	MD	06/23/2015	17:19	EST-5	Thunderstorm Wind	61 kts. EG	0	0	3.00K	0.00K
COOKSVILLE	HOWARD CO.	MD	02/24/2016	18:06	EST-5	Thunderstorm Wind	61 kts. EG	0	0	0.00K	0.00K
LISBON	HOWARD CO.	MD	03/01/2017	13:40	EST-5	Thunderstorm Wind	61 kts. EG	0	0	0.00K	0.00K
LONG CORNER	HOWARD CO.	MD	11/02/2018	19:18	EST-5	Thunderstorm Wind	61 kts. EG	0	0	0.00K	0.00K
HIGHLAND	HOWARD CO.	MD	05/23/2019	14:23	EST-5	Thunderstorm Wind	61 kts. EG	0	0	0.00K	0.00K
CLARKSVILLE	HOWARD CO.	MD	05/23/2019	14:30	EST-5	Thunderstorm Wind	61 kts. EG	0	0	0.00K	0.00K
GLENELG	HOWARD CO.	MD	05/23/2019	14:30	EST-5	Thunderstorm Wind	61 kts. EG	0	0	0.00K	0.00K
SAVAGE	HOWARD CO.	MD	05/23/2019	14:32	EST-5	Thunderstorm Wind	61 kts. EG	0	0	0.00K	0.00K
SAVAGE	HOWARD CO.	MD	05/23/2019	14:36	EST-5	Thunderstorm Wind	70 kts. EG	0	0	0.00K	0.00K
ALPHA	HOWARD CO.	MD	05/26/2019	20:13	EST-5	Thunderstorm Wind	61 kts. EG	0	0	0.00K	0.00K
Totals:								0	0	3.00K	0.00K

[397]

ate_dd=01andbeginDate_yyyy=1969andendDate_mm=10andendDate_dd=01andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND. (last accessed October 1, 2019).

[393] Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(C)+Thunderstorm+WindandbeginDate_mm=01andbeginDate_dd=01andbeginDate_yyyy=1969andendDate_mm=10andendDate_dd=01andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND. (last accessed October 1, 2019).

[394] Some property damage figures are still not updated. NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?windfilter=000andsort=DTandstatefips=24,MARYLANDandcounty=HOWARD:27andeventType=(C)+Thunderstorm+WindandbeginDate_yyyy=1950andbeginDate_mm=01andbeginDate_dd=01andendDate_yyyy=2019andendDate_mm=10andendDate_dd=01. (last accessed October 1, 2019).

[395] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $72,500. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

[396] The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $180,600. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

[397] NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?windfilter=060andsort=DTandstatefips=24,MARYLANDandcounty=HO

Additional significant Thunderstorm/High Wind Events that have impacted Howard County are described below. A significant Thunderstorm/High Wind Event is an event over 60 kts.

Notable Thunderstorm/ High Wind Events in Howard County:

July 30th, 1996 - A severe thunderstorm moved from east to west across the County. The storm brought down trees and power lines, and caused an estimated $24,237[398] in property damage and another $3,176[399] in crop damage.

August 26th, 2003 - A line of severe thunderstorms with winds up to 78 mph moved across the County during the afternoon hours. There were numerous reports of downed trees and power lines throughout the County and caused an estimated $20,825[400] in property damage.

June 1st, 2006 - A strong storm system moved through the area. The winds from these storms caused $31,767[401] in damage.

September 28th, 2006 - As a cold front moved into the region during the afternoon, it spawned several thunderstorms. The most intense thunderstorm occurred along the Interstate 95 Corridor. In total, the storms caused an estimated $44,474[402] in property damage.

June 29th, 2012 – A linear formation of strong thunderstorms, known as a derecho, traveled from the Midwest (Indiana) to the Mid-Atlantic region, impacting the County. The straight-line winds related to this event were above 60 mph, with reports of winds exceeding 80 mph.[403] the damage to trees and electric power infrastructure was extensive and widespread. In total, the storms caused $ 32,754[404] in reported property damage.

NOAA categorized High Wind events separately on their database. The following information relates to High Wind events specifically. There were eight High Wind Events reported between 1950 and October

WARD:27andeventType=(C)+Thunderstorm+WindandbeginDate_yyyy=2013andbeginDate_mm=01andbeginDate_dd=01andendDate_yyyy=2019andendDate_mm=10andendDate_dd=01. (last accessed October 1, 2019).

398 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $20,600. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

399 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $2,700 . Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

400 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $17,700. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

401 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $27,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

402 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2010 was $37,800. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

403 The data specific to this event was found in the United States Commerce Department's Service Assessment, *The Historic Derecho of June 29, 2012*. https://www.weather.gov/media/publications/assessments/derecho12.pdf

404 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 2012 was $29,151 (as reported by the Howard County Department of Finance). Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

2019 in Howard County. Additionally, there was only one significant High Wind Event reported between 1950 and October 2019. That event occurred in Long Corner, Howard County, Maryland, on November 2nd, 1997 causing $1,598[405] in property damage.[406]

Howard County: High Winds from 1950 to October of 2019

(Source: NOAA/NCDC)

Location	County/Zone	St.	Date	Time	T.Z.	Type	Mag	Dth	Inj	PrD	CrD
Totals:								0	0	0.00K	0.00K
CENTRAL AND SOUTHEAST HOWARD (...	CENTRAL AND SOUTHEAST HOWARD (...	MD	02/14/2015	11:15	EST-5	High Wind	50 kts. MG	0	0	0.00K	0.00K
CENTRAL AND SOUTHEAST HOWARD (...	CENTRAL AND SOUTHEAST HOWARD (...	MD	04/03/2016	09:08	EST-5	High Wind	50 kts. EG	0	0	0.00K	0.00K
NORTHWEST HOWARD (ZONE)	NORTHWEST HOWARD (ZONE)	MD	02/12/2017	22:55	EST-5	High Wind	52 kts. EG	0	0	0.00K	0.00K
CENTRAL AND SOUTHEAST HOWARD (...	CENTRAL AND SOUTHEAST HOWARD (...	MD	02/12/2017	22:58	EST-5	High Wind	52 kts. EG	0	0	0.00K	0.00K
CENTRAL AND SOUTHEAST HOWARD (...	CENTRAL AND SOUTHEAST HOWARD (...	MD	03/02/2018	05:00	EST-5	High Wind	50 kts. EG	0	0	0.00K	0.00K
NORTHWEST HOWARD (ZONE)	NORTHWEST HOWARD (ZONE)	MD	03/02/2018	05:00	EST-5	High Wind	50 kts. EG	0	0	0.00K	0.00K
NORTHWEST HOWARD (ZONE)	NORTHWEST HOWARD (ZONE)	MD	02/25/2019	04:21	EST-5	High Wind	50 kts. EG	0	0	0.00K	0.00K
CENTRAL AND SOUTHEAST HOWARD (...	CENTRAL AND SOUTHEAST HOWARD (...	MD	02/25/2019	04:21	EST-5	High Wind	50 kts. EG	0	0	0.00K	0.00K
Totals:								0	0	0.00K	0.00K

407

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

Future Likelihood of a Tornado/Wind Storm in Howard County	
Historical Average (time period)	17 events (1975-2019)
Historical Annual Probability	30%+ chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	11-30% chance of annual occurrence

405 The figure has been adjusted for inflation and is provided in 2019 dollars. The originally reported number in 1997 was $1,000. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).

406 NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(Z)+Strong+WindandbeginDate_mm=01andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=01andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 1, 2019).

407 NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(Z)+High+WindandbeginDate_mm=01andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=01andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 1, 2019).

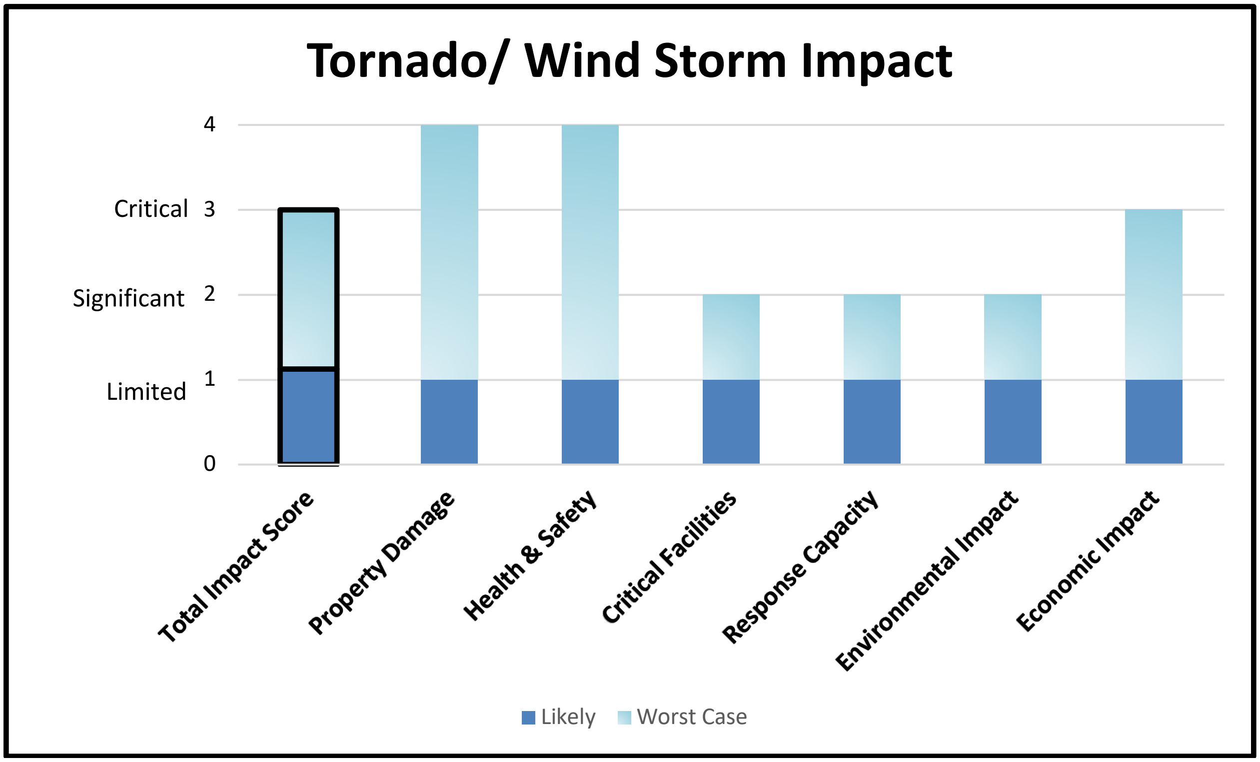
Future Likelihood Score[73]	3.1 (Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: Subject Matter Experts considered that the future likelihood of tornadoes occurring within the County may increase due to climate change and the recent pattern of the storms occurring more frequently within the County. The future annual probability of the event is 11-30% chance of annual occurrence, or, one event every 3-9 years.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes public perceptions of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Tornado/Wind Storm Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* From one minute to one hour.	*Short.* From seconds to five minutes.
DURATION	*Short.* Seconds to 30 minutes.	*Short.* Seconds to ten minutes.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

<table>
<tr><th colspan="4">Tornado/Wind Storm Consequence Analysis
Likely</th></tr>
<tr><th>CATEGORY</th><th>RANKING</th><th colspan="2">DESCRIPTION</th></tr>
<tr><td>PROPERTY DAMAGE</td><td>Limited</td><td colspan="2">▪ Up to 1% of critical and non-critical infrastructure will be damaged.
▪ Some roof shingles and downed trees expected- some roads impassable.
▪ There is a need for temporary shelter.</td></tr>
<tr><td>HEALTH AND SAFETY</td><td>Limited</td><td colspan="2">▪ Zero deaths are expected. Automobile accidents, flying debris, or sheltering in an unsafe location are the most common causes of death.
▪ Zero to five injuries are expected. Automobile accidents, flying debris, or sheltering in an unsafe location are the most common causes of injuries.</td></tr>
<tr><td>CRITICAL FACILITIES</td><td>Limited</td><td colspan="2">▪ <u>Utilities</u> – No critical facilities or essential functions will be out of service.
▪ <u>Information/Communications</u> – No critical facilities or essential functions will be out of service. Minor disruption to power.
▪ <u>Transportation</u> – Possible temporary road closures due to downed trees. Minor disruption to transportation.</td></tr>
<tr><td>RESPONSE CAPACITY</td><td>Limited</td><td colspan="2">▪ <u>Police</u> – Local resources adequate. Low impact to response capability or continuity of operations.
▪ <u>Fire and Rescue</u> – Local resources adequate
▪ <u>Health</u> – Local resources adequate. HD operations will not be affected.
▪ <u>Public Works</u> – Local resources adequate. No impact response capability and continuity of operations.</td></tr>
<tr><td>ENVIRONMENTAL IMPACT</td><td>Limited</td><td colspan="2">▪ Minimal impact and downed trees throughout area is expected.
▪ Limited environmental impact is expected.</td></tr>
<tr><td>ECONOMIC IMPACT</td><td>Limited</td><td colspan="2">▪ Limited amount loss in dollar value.</td></tr>
<tr><td>TOTAL IMPACT[408]</td><td>Limited</td><td colspan="2">▪ Total Impact Score: 1.125 on a scale of 1 (Limited) to 4 (Catastrophic).</td></tr>
<tr><td colspan="2">Limited</td><td>Significant</td><td>Critical | Catastrophic</td></tr>
</table>

[408] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

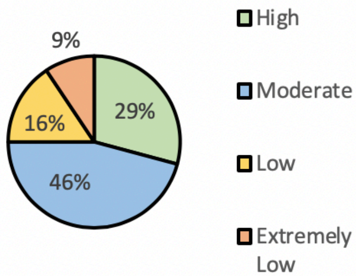
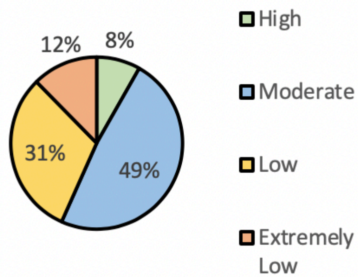
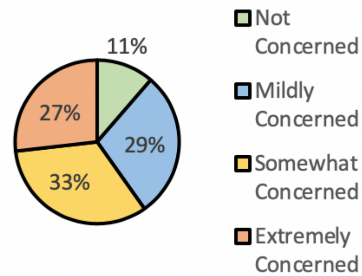
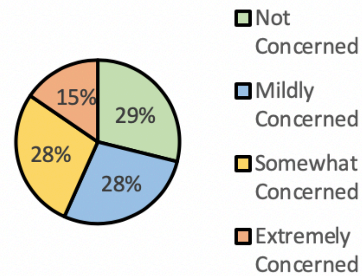
Tornado / Wind Storm Consequence Analysis Worst-Case		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Catastrophic*	▪ Unknown critical and non-critical infrastructure will be damaged. ▪ Traffic Signal damage, debris on roadway, downed trees, and significant power line damage are expected. ▪ Some damage to critical and non-critical infrastructures. ▪ Roof damage, glass blown into offices, loose materials blown all over, and buildings blown off site are expected. ▪ Significant structural damage, it will be catastrophic since all in the path will be damaged or destroyed.
HEALTH AND SAFETY	*Catastrophic*	▪ Three deaths are expected. Automobile accidents, flying debris, and structure collapse are the most common causes of death. ▪ 100 injuries are expected. Broken/fractured bones, internal bleeding, concussions, respiratory distress/arrest are the most common causes of injuries.
CRITICAL FACILITIES	*Significant*	▪ *Utilities* – Days to weeks shut down of critical facilities is expected. ▪ *Information/Communications* – Days to weeks shut down of critical facilities is expected. ▪ *Transportation* – One to two days of shutdown are expected. Traffic signals, damages to schools, fire stations, and County offices are out of service.
RESPONSE CAPACITY	*Significant*	▪ *Police* – Significant and long-lasting need for state or federal assistance. High impact to response capability. Additional manpower will be needed and schedule changes to departmental personnel. Ability to respond and handle minor calls will be affected. Alternate site will be required if building is damaged or destroyed. Sheriff's Office may be needed to support operations. ▪ *Fire and Rescue* – Moderate need for state or Federal assistance. Will require mutual aid response. Damage to utilities expected. ▪ *Health* – Moderate need for state or federal assistance. HD essential services will be operating from an alternate location if the structure is unsafe or damaged. Other services will operate virtually or remotely. ▪ *Public Works* – Moderate need for state or federal assistance. Minimal to critical impact on operations.
ENVIRONMENTAL IMPACT	*Significant*	▪ Minimal direct impact on air, water, and land resources, although can cause a loss of individual plants and animal. ▪ Downed trees and limbs expected in affected area(s). ▪ Possible air, water, and land pollution if industrial manufacturing plants or sewage treatment plants are damaged causing them to release gases or untreated liquids.
ECONOMIC IMPACT	*Critical*	▪ Transportation system, structural and infrastructure impacts on economic consequences.
TOTAL IMPACT[409]	***Critical***	▪ **Total Impact Score: 3 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

[409] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

Tornado / Wind Storm Hazard Public Perception			
PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD	**PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD**	**CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY**	**CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY**
 *Average: 2.95* *Low - Moderate*	 *Average: 2.53* *Low - Moderate*	 *Average: 2.75* *Mildly Concerned - Somewhat Concerned*	 *Average: 2.30* *Mildly Concerned - Somewhat Concerned*

Wildfire

I. OVERVIEW

The Overview section defines the hazard and summarizes the hazard risk profile.

Definition

This section defines the scope of the hazard category. The terminology and characterization established in this section should be consistent throughout all Howard County planning documents.

Wildfires are uncontrolled forest fires, grassland fires, rangeland, or urban-interface fires which consume natural fuels and spread in response to the environment.[410] Wildfires can be either a natural phenomenon or human-caused. The frequency and severity of wildfires depends on both weather and human activity. Wildfires can occur any month in Maryland, but peak in the spring and fall. During these seasons, deciduous trees are bare, allowing sunlight and wind to reach the ground and dry any available fuels. The relative humidity of the air is also lower and, combined with a breeze, creates the conditions for wildfires to spread rapidly.

Risk Profile

The Risk Profile section presents the Risk Score for the hazard in a range from 1 (lowest risk) to 4 (highest risk). Risk Score is a function of Likelihood and Consequence.

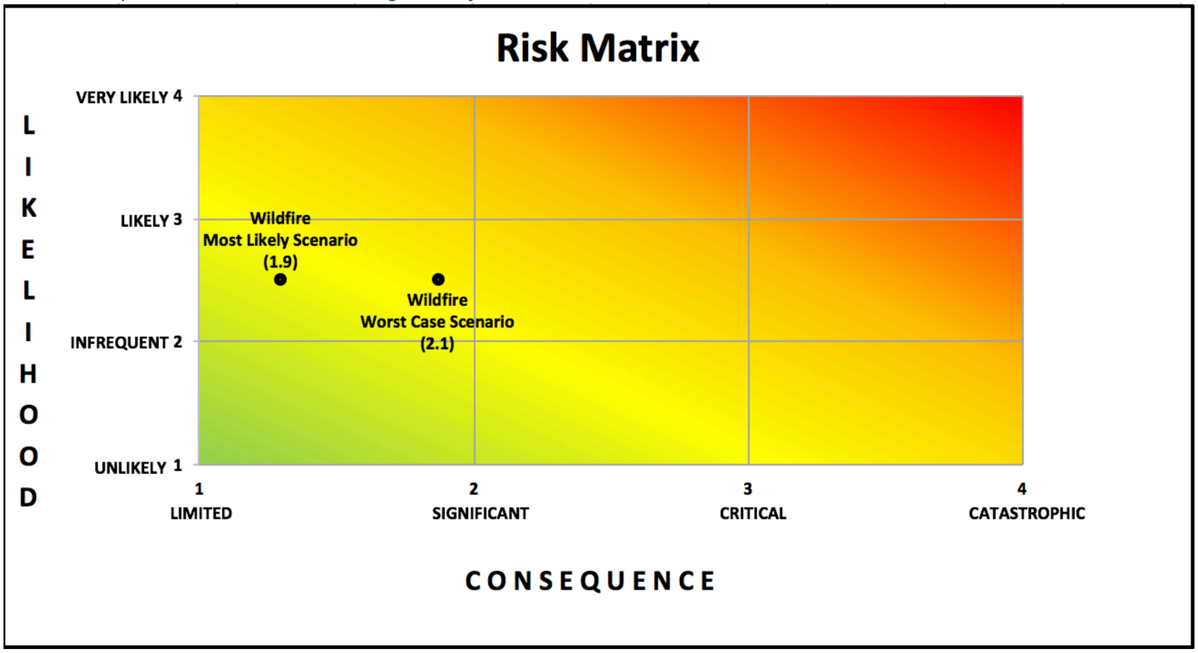
Wildfire Risk Profile					
LIKELIHOOD	**Risk Assessment Category**	**Likely Hazard Scenario**	**Worst-Case Hazard Scenario**	**Weight**
	Likelihood	2.5 Infrequent-Likely		50%
CONSEQUENCE	**Impact**	1 Limited	1.6 Limited-Significant	40%
	Warning Time	4 Short	4 Short	5%
	Duration	1 Short	2 Moderate	5%
TOTAL RISK SCORE		**1.9**	**2.1**	

**The Likelihood Score reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.*

[410] See also *NWCG Glossary of Wildland Fire Terminology*, http://www.nwcg.gov/pms/pubs/glossary/w.htm#Wildfire (last accessed October 1, 2019).

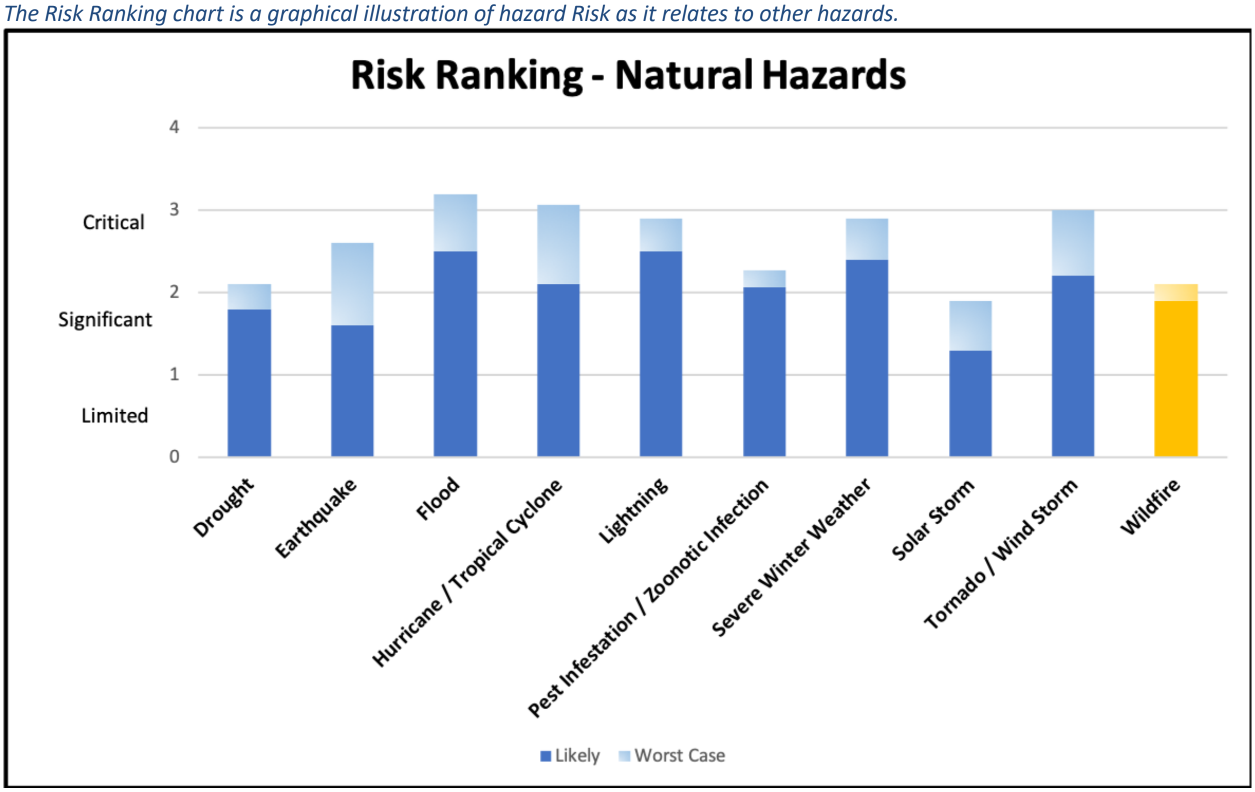
Risk Matrix

The Risk Matrix chart is a graphical illustration of hazard Risk as a function of Likelihood and Consequence. Consequence includes the Impact, Duration, and Warning Time of the Hazard.



Risk Ranking

The Risk Ranking chart is a graphical illustration of hazard Risk as it relates to other hazards.



Where no Worst-Case bar is visible, Worst-Case Risk is equivalent to Likely Risk.

II. HAZARD CHARACTERISTICS

The Hazard Characteristics section provides a detailed characterization of the hazard and the local context as it relates to the hazard.

Description of the Hazard

Wildfires can play a positive or destructive role in the evolution of an ecosystem. Forest and grassland fires can occur throughout the year. In Maryland, the greatest threat of wildfires occurs during the spring and fall seasons.[411] The length and severity of the burning season largely depends on weather conditions. During the spring, the region experiences low humidity, high winds, below-normal precipitation, and high temperatures, which all contribute to high fire danger. Wildfires can also occur in late fall. Depending on weather conditions, the month of November also generally has a high rate of wildfires.[412]

Local Context

The Local Context section describes community attributes that affect the likelihood of the hazard's occurrence or vulnerability to the hazard's consequences.

The severity in Howard County has been historically very low, and the duration of wildfires has ranged from a matter of hours to several days. Urban interface fires[413] are becoming increasingly problematic in Maryland. As people continue to live and work near wildland areas, the threat to private property from wildfires increases. This phenomenon is growing in Howard County as suburbanization and population growth continues in the County.

Although urban interface fires have the greatest possibility to cause property damage, the potential for wildfires exists throughout the entire County. The greatest risk for significant wildfires to occur would be in large, forested areas such as the Patapsco State Park and the Hugh Thomas Wildlife Management Area to the north. The Patapsco River Valley, where Patapsco State Park is located, is characterized by steep slopes exceeding 20% grade. In addition, dense vegetation and hardwoods provide ample fuel for fire. In the southern portion of the County, the Rocky Gorge Reservoir Park and the Patuxent Wildland Area are also areas at risk for potential wildfires. The Patuxent Wildland Area is a State-designated wildland, which restricts the ability to reduce fuels or create ingress routes. In addition, the characteristics of the Patuxent Wildland Area are similar to the Patapsco State Park, where dense vegetation and hardwoods provide high fuel loads.

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[411] Maryland Department of Natural Resources. Wildland Fire in Maryland. Retrieved from https://dnr.maryland.gov/forests/Pages/wfm.aspx (last accessed October 1, 2019).

[412] For additional information on wildfires, see generally Maryland Department of Natural Resources. Wildland Fire in Maryland. Retrieved from https://dnr.maryland.gov/forests/Pages/wfm.aspx (last accessed October 1, 2019).

[413] The urban interface is defined as the area where structures and other human development blend with undeveloped wildland. See *Technical Guide to Map and to Characterize Wildland-Urban Interface (WUI)*, http://www.fireparadox.org/technical_guide_wildland_urban_interfaces_print.php (last accessed October 8, 2019).

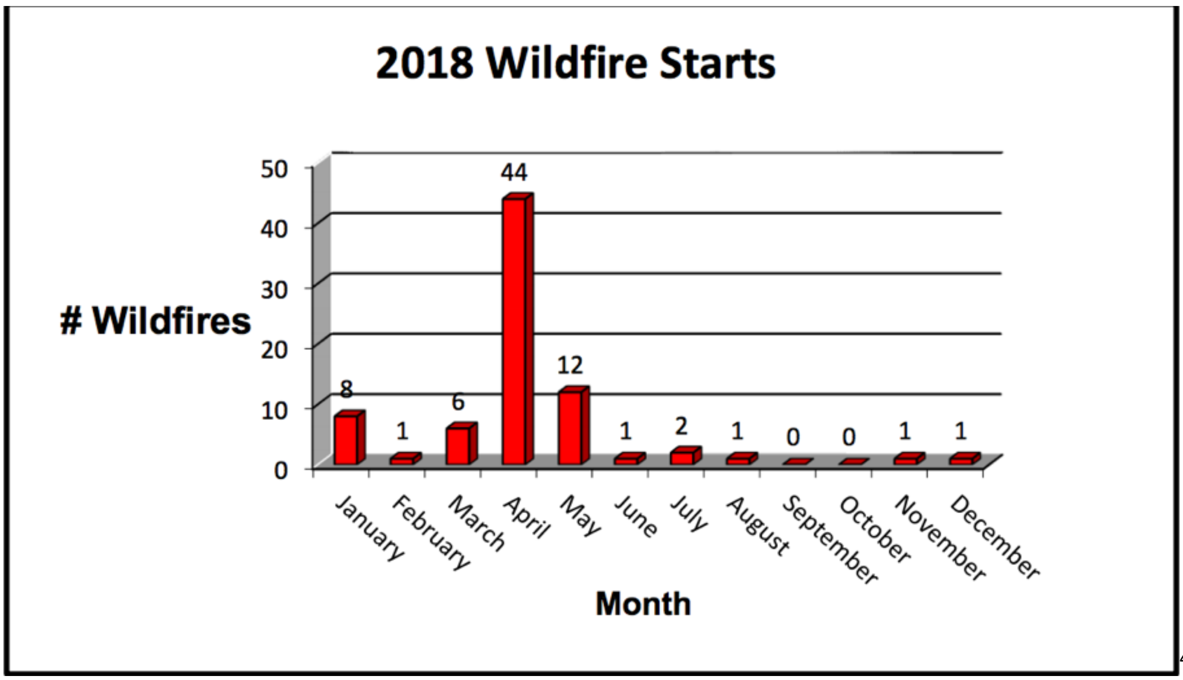
III. LIKELIHOOD ANALYSIS

The Likelihood Analysis section characterizes the historical occurrence and future likelihood of the hazard in the planning area.

Occurrence of the Hazard

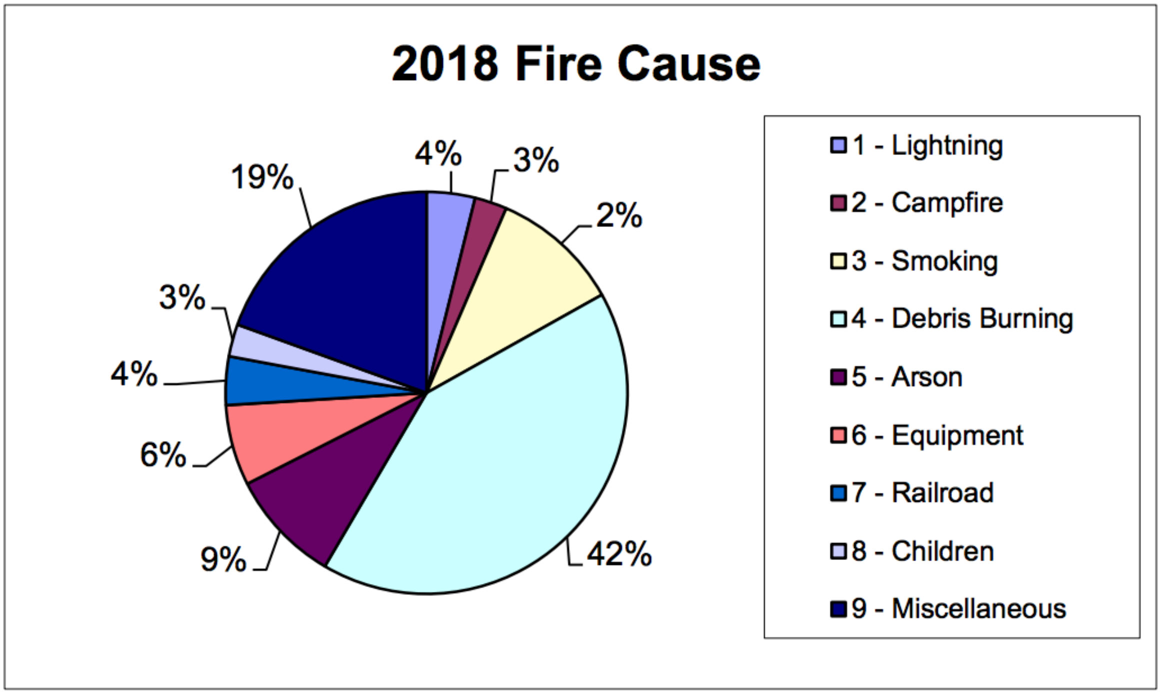
The Occurrence of the Hazard section details the historical occurrence of the hazard in the planning area.

In the United States generally, wildfires have ranked as one the top costliest and deadliest hazards. In 2016, Wildfires cost $179 million[414] in losses ranking it the fifth costliest hazard that year.[415] Wildfires incident data shows fires in Maryland occur relatively frequently. In an average year, "the Maryland Forest Service responds to an average of 325 wildfires that burn more than 3,200 acres of forest, brush, and grasses. Fire departments respond to over 5,000 wildfire incidents per year."[416] In 2018, Maryland experienced a total of 77 wildfires.[417]



[418]

[414] When accounting for inflation, this number would be $2,458,372 in 2019. Citation: US Inflation Calculator. Retrieved from https://www.usinflationcalculator.com/ (last accessed October 10, 2019).
[415] Center for Emergency Management and Homeland Security, Arizona University. 2016 U.S. Hazard Losses. Retrieved from https://cemhs.asu.edu/sites/default/files/summary2016_v16.pdf (last accessed October 8, 2019).
[416] Maryland Department of Natural Resources. Wildland Fire in Maryland. Retrieved from https://dnr.maryland.gov/forests/Pages/wfm.aspx (last accessed October 1, 2019).
[417] Maryland Department of Natural Resources. Maryland Forest Service Wildland Fire Program 2018 Annual Wildland Fire Report. Retrieved from https://dnr.maryland.gov/forests/Documents/fire/2018AnnualWildfireReport.pdf (last accessed October 8, 2019).
[418] Maryland Department of Natural Resources. Maryland Forest Service Wildland Fire Program 2018 Annual Wildland Fire Report. Retrieved from https://dnr.maryland.gov/forests/Documents/fire/2018AnnualWildfireReport.pdf (last accessed October 8, 2019).



[419]

The table below summaries the total number of fires and acres for the State of Maryland between 2004 and 2018.[420]

Fires and Acres Burned in Maryland from 2004 - 2018[421]

(Source: Maryland Department of Natural Resources)

Year	Total Number of Fires	Total Acres Burned
2004	253	3,149
2005	441	4,344
2006	753	6,074
2007	622	5,102
2008	583	2,339
2009	408	4,853
2010	170	1,503
2011	125	8310
2012	159	837
2013	122	161
2014	118	1721
2015	158	1078

419 Maryland Department of Natural Resources. Maryland Forest Service Wildland Fire Program 2018 Annual Wildland Fire Report. Retrieved from https://dnr.maryland.gov/forests/Documents/fire/2018AnnualWildfireReport.pdf (last accessed October 8, 2019).

420 The information provided was the most up to data available at the creation of the 2019 HIRA, 2019 data was not available at the time of the creation of the 2019 HIRA.

421 Maryland Department of Natural Resources. Maryland Forest Service Wildland Fire Program 2018 Annual Wildland Fire Report. Retrieved from https://dnr.maryland.gov/forests/Documents/fire/2018AnnualWildfireReport.pdf (last accessed October 8, 2019).

Year	Total Number of Fires	Total Acres Burned
2016	121	242
2017	107	2175
2018	77	359

Notable Incidents in Howard County

The NCDC[422] indicated there were no wildfire incidents between 1950 and October 2019 within Howard County. However, additional research does reflect that wildfires have occurred within Howard County. According to the SHELDUS database[423], two wildfires caused several thousand dollars' worth of damage in 1963. According to the 2015 HIRA, there were 6,919 Wildfire Hazard events recorded from 1995-2001. Periodical sources were also consulted to identify past wildfire events for Howard County.

Based on this research, some recent wildfire events are described below.

- **March 30th, 1999:** A 10-acre brushfire raged for four hours in the Patapsco Valley State Park. Firefighters were then called to a 5-acre brushfire within an hour after extinguishing the park fire. Firefighters responded to four other fires within eight miles of one another. The high number of fires was due to drought-like conditions.
- **March 23rd, 2004:** A brushfire on County land near Oakland Mills High School in Columbia burned 10 acres of land. Fueled by dead corn stalks and trees, the fire raced across an open field before firefighters contained it an hour later.[424]
- **February 19th, 2011.** High winds with gusts up to 45 mph, high temperatures, and low humidity contributed to the start of eight brushfires, which eventually burned down 20 acres. One of the largest fires occurred near the 3800 block of Manor Lane in Ellicott City. A wildfire was also located on Interstate 95 in the Laurel area between MD-198 and the Capital Beltway closing both northbound and southbound lanes until the fire was brought under control.

Additionally, current wildfire data from DFRS reflects the following data relating to the number of wildfires within Howard County:

- FY2016- 116
- FY2017- 135
- FY2018- 112
- FY2019- 57

[422] NOAA. Storm Events Database. Retrieved from https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=(Z)+WildfireandbeginDate_mm=06andbeginDate_dd=01andbeginDate_yyyy=1950andendDate_mm=10andendDate_dd=08andendDate_yyyy=2019andcounty=HOWARD:27andhailfilter=0.00andtornfilter=0andwindfilter=000andsort=DTandsubmitbutton=Searchandstatefips=24,MARYLAND (last accessed October 8, 2019).

[423] See *SHELDUS*, http://webra.cas.sc.edu/hvri/products/sheldus.aspx (last accessed February 28, 2012).

[424] Sentementes, Gus, *Brush Fire Scorches About 10 Acres*, Baltimore Sun, March 24, 2004, available at http://articles.baltimoresun.com/2004-03-24/news/0403240194_1_firefighters-oakland-mills-corn-stalks (last accessed October 1, 2019).

Due to conflicting data reports, a definitive total number of wildfires occurring within Howard County from 1995-2019 cannot be determined. However, based on all the data provided above, there is an estimated number of over 7,300 wildfire hazard events that have occurred in Howard County in the reviewed time period of 1995-2019.

Future Likelihood of the Hazard for Howard County

The Future Likelihood section anticipates the future occurrence rate of the hazard based on historical likelihood and future trends. This section also addresses factors that may cause the future likelihood to deviate from historical trends.

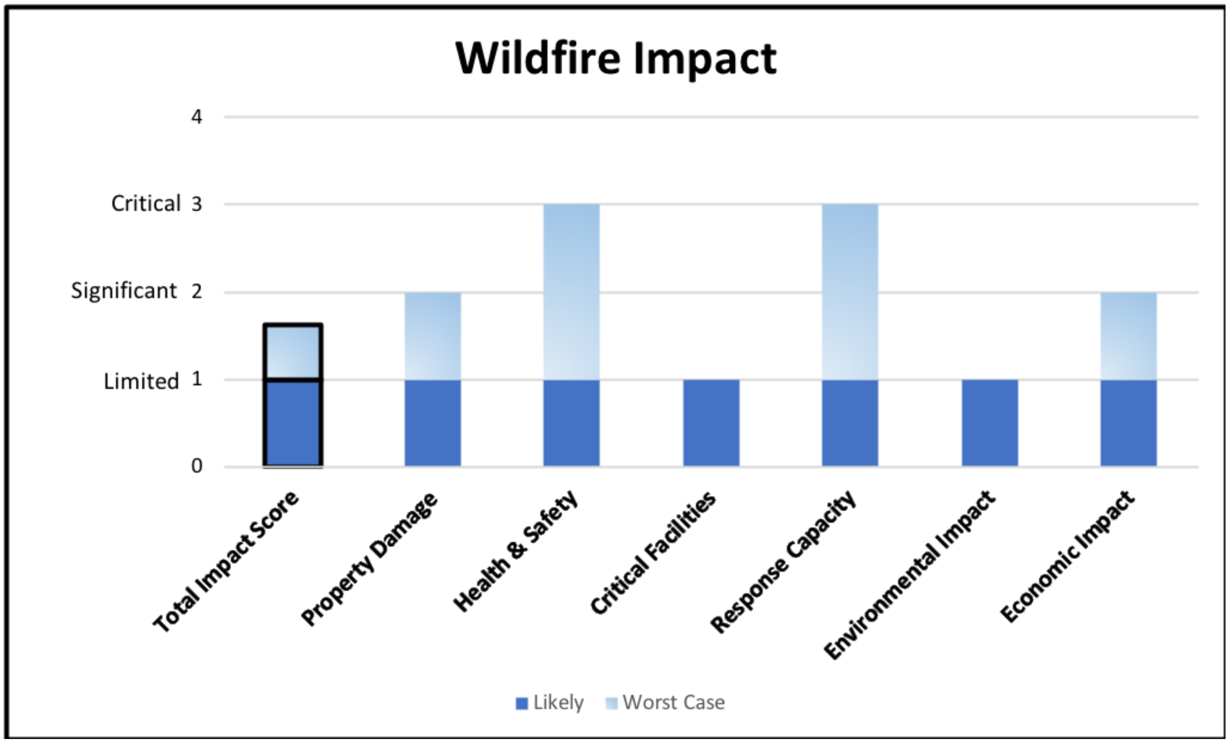
Future Likelihood of a Wildfire in Howard County	
Historical Average (time period)	Estimated over 7,300 events (1995-2019)
Historical Annual Probability	30%+ chance of annual occurrence
Future Likelihood Expected to Deviate from Historical Likelihood (Yes/No)	No
Future Annual Probability	1-30% chance of annual occurrence
Future Likelihood Score[73]	2.5 (Infrequent/Likely)
Future Likelihood reflects the likelihood of any emergency-level hazard event and does not differentiate between Likely and Worst-Case scenarios.	

Considerations: The future annual probability of this hazard is 1-30% chance of annual occurrence, or, one event every 9-99 years. As noted above, wildfire incidents are directly related to weather patterns and antecedent conditions, and thus its probability of occurrences are dynamic. Other considerations include the prevalence of native pine trees within the County and lesser maintenance of fallen trees.

IV. CONSEQUENCE ANALYSIS

The Consequence Analysis section provides a detailed characterization of the anticipated consequences of likely and worst-case hazard events. This section characterizes impacts to property, health and safety, critical facilities, response capacity, the environment, and the economy. This section also characterizes the public perception of each hazard, the perceived impact to personal safety and standard of living, and public confidence in response capability.

Consequence Analysis Overview



Where no Worst-Case bar is visible, Worst-Case impact is equivalent to Likely impact.

Wildfire Warning Time and Duration		
	Likely	**Worst-Case**
WARNING TIME	*Short.* No warning time prior to a wildfire.	*Short.* No warning time prior to a wildfire.
DURATION	*Short.* Five to 25 minutes.	*Short-Moderate.* One to 12 hours.

Consequence Analysis: Likely Hazard Scenario

The Consequence Analysis table details the anticipated consequences of the most likely hazard scenario.

Wildfire Consequence Analysis Likely		
CATEGORY	**RANKING**	**DESCRIPTION**
PROPERTY DAMAGE	*Limited*	▪ 0% of critical and non-critical infrastructure will be damaged. ▪ Scorched earth and destroyed landscaping expected.
HEALTH AND SAFETY	*Limited*	▪ Zero deaths are expected. Smoke and toxic gas is the most common causes of death. ▪ Zero to two injuries are expected. Smoke inhalation and toxic gases are the most common causes of injuries.
CRITICAL FACILITIES	*Limited*	▪ *Utilities -* Shutdown or out of service is unlikely. ▪ *Information/Communications -* Shutdown or out of service is unlikely. ▪ *Transportation –* traffic is shut down for twenty (20) minutes.
RESPONSE CAPACITY	*Limited*	▪ *Police*- Local resources adequate. No impact to response capability or continuity of operations. ▪ *Fire and Rescue* -Local resources adequate. Traffic issues and increased response times may be impacted. ▪ *Health*- Local resources adequate. HD operations will not be affected and will be communicating with the EOC. ▪ *Public Works* - Local resource adequate with minimal to no impact on response capability and continuity of operations. ▪ *DPW-* Mutual aid needed (Fire and Rescue, possibly SHA). Some response calls will be rerouted.
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal impact with a loss to plant and animal life in the immediate area. ▪ Limited environmental impact is expected.
ECONOMIC IMPACT	*Limited*	▪ Limited loss in dollar value. ▪ Limited economic consequences.
TOTAL IMPACT[425]	***Limited***	▪ **Total Impact Score: 1 on a scale of 1 (Limited) to 4 (Catastrophic).**

Limited	*Significant*	*Critical*	*Catastrophic*

425 The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

Consequence Analysis: Worst-Case Hazard Scenario

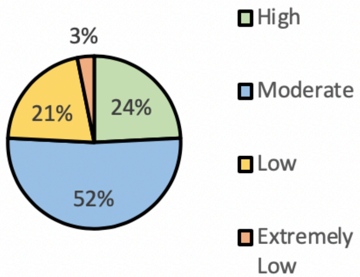
The Consequence Analysis: Worst-Case table details the anticipated consequences of the worst-case hazard scenario that could reasonably occur within the jurisdiction.

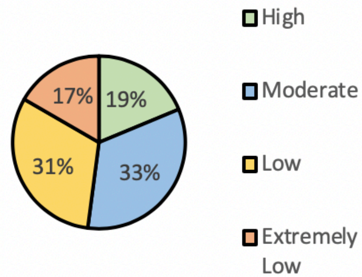
Wildfire Consequence Analysis **Worst-Case**				
CATEGORY	**RANKING**	**DESCRIPTION**		
PROPERTY DAMAGE	*Significant*	▪ Critical and non-critical infrastructure will be damaged. Mostly private property damage and some County buildings depending on proximity are expected to be damaged. ▪ Major structural damage, and downed wires are expected. ▪ Structure fires and possible paving damage is expected. ▪ Fire damage occurring to residence and vehicles in the urban/ wild land interface is expected.		
HEALTH AND SAFETY	*Critical*	▪ Zero to three deaths are expected. Smoke inhalation and toxic gases are the most common causes of death. ▪ Zero to 15 injuries are expected. 2nd and 3rd degree burns, smoke inhalation, and toxic gases are the most common causes of injuries.		
CRITICAL FACILITIES	*Limited*	▪ *Utilities* - Less than a day of shut down is expected. ▪ *Information/Communications* - Access to some buildings may be out of service. Six months shut down for burned structures is expected. ▪ *Transportation –* Significant disruption to travel. Possible lane shifts, or partial closures will occur. Evacuations will cause further delays. ▪ Some roads or emergency vehicle access needs will be shut down.		
RESPONSE CAPACITY	*Critical*	▪ *Police*-Local resources adequate. No impact to response capability or continuity of operations. ▪ *Fire and Rescue-* Moderate need for state or Federal assistance. Most likely will need assistance from Department of Natural Resources in wild land effort. ▪ *Health*- Moderate need for state or Federal assistance. Virtual monitoring and communicating with Web EOC. ▪ *Public Works-* Moderate need for state or federal assistance with some impact assisting other departments. ▪ Mutual aid needed. All non-emergency fire and police calls will be delayed.		
ENVIRONMENTAL IMPACT	*Limited*	▪ Minimal impact with a temporary spike in air pollution and a loss of plant and animal life in the immediate area of the burns. ▪ Limited environmental impact is expected.		
ECONOMIC IMPACT	*Significant*	▪ Significant amount loss of dollar value. ▪ Residential and agricultural areas of economic consequences.		
TOTAL IMPACT[426]	***Limited-Significant***	▪ **Total Impact Score: 1.625 on a scale of 1 (Limited) to 4 (Catastrophic).**		
Limited		*Significant*	*Critical*	*Catastrophic*

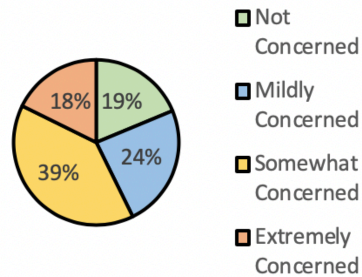
[426] The total impact score is created by Subject Matter Experts weighing the importance of the economic impact, environmental impact, response capacity, critical facilities, health/safety, and property damage for each hazard. These factors are weighed differently, depending on the specific hazard. The subject matter experts were divided into groups where they created one total score per hazard. Those individual scores were then averaged together to create the total impact score you see on the graph.

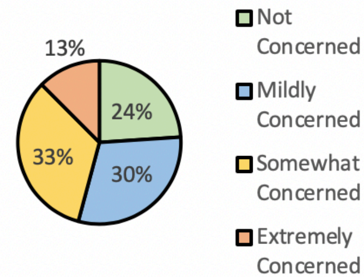
Consequence Analysis: Public Perception

The Consequence Analysis: Public Perception table characterizes the public perception of each hazard. Details include public confidence in personal ability to respond to each hazard, public confidence in Howard County's ability to respond to each hazard, and each hazard's perceived impact to personal safety and standard of living.

<table>
<tr><th colspan="4">Wildfire Hazard
Public Perception</th></tr>
<tr><th>PERCEIVED CONFIDENCE IN HOWARD COUNTY'S ABILITY TO RESPOND AND RECOVER FROM THIS HAZARD</th><th>PERCEIVED CONFIDENCE IN PERSONAL ABILITY TO PROTECT SELF AND FAMILY FROM THIS HAZARD</th><th>CONCERN OVER THE IMPACT TO PERSONAL HEALTH AND SAFETY IF THIS HAZARD WERE TO OCCUR LOCALLY</th><th>CONCERN OVER THE IMPACT TO PERSONAL STANDARD OF LIVING / QUALITY OF LIFE IF THIS HAZARD WERE TO OCCUR LOCALLY</th></tr>
<tr>
<td>

Average: 2.97
Low - Moderate</td>
<td>

Average: 2.54
Low - Moderate</td>
<td>

Average: 2.56
Mildly Concerned - Somewhat Concerned</td>
<td>

Average: 2.34
Mildly Concerned - Somewhat Concerned</td>
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